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OCEAN BARGE CONNECTION SYSTEM DEVELOPMENT

An Investigation Conducted by:

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13. ABSTRACT *(Maximum 200 words)*

The primary objectives of this design/development effort were to review and evaluate the engineering criteria and connection system concept as previously developed by the Naval Facilities Engineering Service Center, as well as to further develop the connection system concept with respect to its design, fabricability and operability as applicable to side-to-side and end-to-end connections. These objectives were met through the performance of the following project tasks: review and evaluation of engineering criteria; review and evaluation of NFESC concept; development of structural layout for the selected alternative; preliminary design of selected alternative and its components; preliminary design of selected connection system support structure; development of modifications to system components; determination of weights, preparation of materials list and development of costs. Additional efforts included analyzing the effect of fabrication tolerances on the design and operability of the connection system; the assumed method of barge module-to-module contact and its effect on the design and operability of the connection system; and a more detailed assessment of barge module motions and its impact on cable snap loading.

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1. GENERAL

1.1 BACKGROUND

Proven connection systems do not presently exist for connecting barge modules in Sea State 3, associated with open seas. Naval Facilities Engineering Service Center (NFESC) was responsible for initiating and completing a project that will allow further advances on barge module connection systems. The NFESC project was documented in March 1995 in a technical memorandum, TM-2067-AMP, entitled "Conceptual Development of Open Sea Module Connection Techniques" (Reference 1).

International Design, Engineering and Analysis Services (I.D.E.A.S.), Inc. was awarded a contract to continue development/design of the NFESC proposed connection system as documented in References 1 and 2 (Reference 2 is also reproduced in Appendix A of this report). This development consisted of seven (7) tasks, each documented by a technical report (References 3 through 9) to inform NFESC of project progress and to solicit their comments. This final design report documents this development work, provides design/development recommendations for enhancing the connection system design development, and suggests future work necessary to further refine the concept.

1.2 OBJECTIVES AND SCOPE

The primary objectives of this design/development work were to:

- review and evaluate the NFESC provided engineering criteria and connection system concept.
- further develop the connection system concept with respect to its design, fabricability, and operability as applicable to side-to-side and end-to-end connections.

These objectives were met through the performance of project tasks defined by the work scope for this design/development. Thus, the initial work scope consisted of eight (8) distinct tasks:

- review and evaluation of engineering criteria
- review and evaluation of NFESC concept
- development of structural layout for the selected alternative
- preliminary design of selected alternative and its components
- preliminary design of selected connection system support structure
- development of modifications to system components
- determination of weights, preparation of materials list and development of costs
- preparation of a report to NFESC

This work scope was enhanced as the project proceeded to cover special considerations not envisioned at the start of the project. Such considerations included the effect of fabrication tolerances on the design and operability of the connection system, the assumed method of barge module-to-module contact and its effect on the design and operability of the connection system, and a more detailed assessment of barge module motions and its impact on cable snap loading.

2. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

2.1 SUMMARY

This report presents the task development work performed by I.D.E.A.S. for NFESC on their Ocean Barge Module Connection system development. The basis for this work was the previous development work undertaken by NFESC (Reference 1) and the associated concept drawings (Reference 2, reproduced in Appendix A). The present work was performed in seven (7) development tasks (Tasks 20, 30, 40, 50, 60, 70 and 80) as specified in the contract proposal. Brief technical reports (References 3 through 9) were issued at the end of each task to document the development findings, solicit NFESC comments and serve as a basis for subsequent tasks.

The Task 20 scope was to review and evaluate the NFESC specified and/or desired engineering criteria applicable to the connection system development. The primary objective of this task was to ensure that a connection system complying with these criteria will meet other defined system requirements and to identify conflicting criteria or criteria where trade-offs would be needed due to fabrication, cost, operation or other considerations. Task 20 is documented in Reference 3 and summarized in Section 4 of this report.

The Task 30 scope was to review and evaluate the NFESC connection system concept presented in References 1 and 2 with respect to the connection of 40 ft long, 24 ft wide, 8 ft deep barge modules. The connection operation was assumed to include an initial pulling together of barge modules to form a temporary flexible connection followed by rigid connection of the modules using the NFESC connector assembly frame and stabbing pin concept. The primary objective of this task was to assess the compatibility of the concept with respect to the design functional requirements and engineering criteria and to further review potential problem areas associated with both end-to-end and side-to-side connections, if any, and identify applicable solutions. Task 30 is documented in Reference 4 and summarized in Section 5 of this report.

The Task 40 scope was to develop an initial structural layout for the NFESC connection concept. The work scope for this task was to perform further development work to determine the most efficient structure layout and main component sizes to meet the engineering requirements based on an upper-bound environmental/motions criteria developed from the end-to-end connection of two modules. This work was very preliminary in nature and the specific development results were modified in subsequent tasks as further development work was completed. In the end, two connection system alternatives were designed, documented and one of these alternatives recommended for further development. Task 40 is documented in Reference 5 and summarized in Section 6 of this report.

The Task 50 scope was to perform preliminary design of the NFESC connection concept. The work scope for this task was to size the connecting cable, the connection system stabbing pins, and the connection system assembly frame based on design operating requirements recommended in Reference 1. The developed cable design represents a conservative upper-bound design for budgetary purposes that should be further refined once future model test results are available for multiple module and side-to-side connections. This sizing was supported by a detailed assessment of snap load effects on the cable for various cable size and length combinations. Additional preliminary non-linear dynamic motions analyses were also performed to validate the assessment work. The stabbing pin and assembly frame preliminary design development is the result of engineering space frame analysis and code checking per relevant design codes. Task 50 is documented in Reference 6 and summarized in Section 7 of this report.

The Task 60 scope was to perform preliminary design of the barge module support structure for the NFESC connection concept. The scope of this task was to size the watertight enclosure structure surrounding each connector assembly frame for weight estimation and budgetary purposes. This structure is to be integrated into the overall barge structure design and therefore the development of design details is premature until the overall barge design concept is further progressed. Task 60 is documented in Reference 7 and summarized in Section 8 of this report.

The Task 70 scope was to develop a materials list, determine weights and estimate costs for the connection structure and components directly applicable to the NFESC connection concept. These items were developed for the connection cable, the connector assembly frame and the barge module support structure. Material lists, weights and costs were developed for two (modified) connection system concept alternatives. Task 70 is documented in Reference 8 and summarized in Section 9 of this report. Appendix C contains the material lists by component items and a summary list by material for both connection system alternatives.

The Task 80 scope was to summarize previously considered modifications and/or improvements to components of the NFESC connection system concept and to further develop these modifications, as necessary. This task essential improved upon and finalized the work of previous tasks (Tasks 40, 50 and 60). Modifications required to meet engineering criteria were developed for the connecting cable, stabbing pin and assembly frame based on appropriate analyses for the design operating conditions recommended in Reference 1. While no major changes were made in the general NFESC concept, the recommended changes will provide a connection system that will be adequate for the imposed design loadings. Task 80 is documented in Reference 9. The task is presented in Section 10 of this report as a summary of modifications to the NFESC connection system concept.

As the development work progressed, it became apparent that special consideration must be given to:

- fabrication tolerances
- module-to-module contact
- side-to-side versus end-to-end connections
- number of connections

These considerations were added to the basic scope in order to further enhance the quality of the development. It was determined that the project objectives could not be achieved unless the connection system was shown to function as intended. Thus, a detailed evaluation of fabrication tolerances for connection system components and their effect on the design and operability of the connection system was performed. This assessment strongly suggests that the barge fabrication and connector assembly frame tolerance effects be decoupled from the connection system design as a matter of design philosophy. This decoupling can be most readily achieved if the barge module-to-module contact occurs at the face plate of the connector assembly frames rather than at the barge surface structure, resulting in a connection system concept that should be lighter, less complicated and easier to activate in at-sea conditions.

Initially, every module was assumed to have eight (8) connector assemblies (i.e., two connectors on each module face). Later, it was determined that six (6) connector assemblies (i.e., only one on each side) would be adequate.

2.2 CONCLUSIONS

2.2.1 General

The NFESC connection system concept is, in general, a viable structural concept for connecting ocean barge modules in Sea State 3 environmental conditions and for permitting the operation of connected barge modules in Sea State 5 environmental conditions. The concept requires some modifications in order to meet the desired fabrication, cost and design installation and operating conditions. These modifications include design enhancements to decouple major fabrication tolerances from the connection design, and design material and size revisions.

The presence of six connector assemblies on barge modules will reduce the available module displacement by about 9 percent since the connector assemblies are open to the ocean.

The estimated additional weight of a barge module connection system is about 40 kips (20 tons), assuming six (6) connector assemblies per barge module. Approximately 45 percent of this added weight is attributable to the barge module support structure needed to enclose and support the connector assembly frames. This added weight will increase the stillwater draft of a barge module by about 0.7 feet.

The estimated weight of one assembly frame and stabbing pin is about 3,600 lbs; the stabbing pin weighs about 950 lbs and the assembly frame weighs about 2,650 lbs. This exceeds the target weight of 3,000 lbs by about 600 lbs. A more detailed finite element analysis of the assembly frame and/or less conservative design operating loads may result in a reduction in the weight of the stabbing pin and assembly frame but a total weight less than 3,000 lbs will probably not be achievable unless the stabbing pin is shortened considerably, which may not be possible due to the stabbing pin spring length requirement to resist impact loading.

2.2.2 Fabrication Tolerances

The connection system design development should decouple the assembly frame fabrication tolerances from the barge construction tolerances. In this way, barge construction tolerances can meet standard shipyard practice and not affect overall barge cost and fabrication schedule. To accomplish this objective, a shimmed guide system (as proposed in this report, or similar) to accurately locate the subsequently installed assembly frames in the barge module support structure should be surveyed and accurately installed in the shipyard.

2.2.3 Module-To-Module Contact

Module-to-module contact at the connector assembly face plates is preferable to contact at the barge module surfaces as this will more readily allow decoupling of the barge fabrication tolerances from the connection system design.

2.2.4 Number and Arrangement of Connectors

The number (6) and arrangement of connectors (two at each module end and one at midspan on each side) should adequately resist imposed loads provided that the connected barge configurations and connection methodology is consistent with the design load capacities of the connectors.

2.2.5 Side-To-Side Versus End-To-End Connections

The connection system design should be adequate for both side-to-side and end-to-end connections provided the connected barge configurations and connection methodology is consistent with the design load capacities of the connectors.

2.2.6 Connection Cable

The connection cable sizing and length will be highly dependent on cable material and other associated equipment such as winch type (e.g., constant tension), associated cable support frames, bollard locations, and mooring schemes and tug pulling force. Two 200 feet by 1 inch diameter IWRC mooring ropes are assumed for weight and budgetary purposes.

2.2.7 Stabbing Pin

The connection system weight is very sensitive to the length of the stabbing pin. Minimizing the stabbing pin length should be a primary design objective.

The NFESC stabbing pin concept is viable with a minor modification to the stabbing nose section to increase its strength and resistance to shear load (e.g., increase tubular thickness to at least 7/8 inch). The connector assembly stabbing pin nose section is also subject to fatigue loads due to longitudinal axial load and shear and local bending moment reversals on the stabbing pin.

2.2.8 Assembly Frame

The NFESC connector assembly frame concept is viable with some modification for resisting the design operating loads. High strength steel throughout is needed in order to meet the design engineering criteria with practical material sizes.

The ability to install each stabbing pin into each assembly frame will be highly dependent on the assembly fabrication tolerances achievable in the fabrication shop. Tolerances should be set as tight as practical.

2.2.9 Barge Module Support Structure

The barge module support structure enclosing the six connector assembly frames should be readily incorporated into an overall barge module design. This structure represents approximately 45 percent of the total added weight of the connector system and should be accounted for when assessing weight dependent aspects of the barge or connection system development.

2.3 RECOMMENDATIONS

2.3.1 Connection Scenario/Arrangement

It is recommended that each assembly frame be installed into barge connector slots based on theoretical distances from module centerlines, allowing decoupling of barge module construction tolerances from those of the assembly frame. Tolerances set shall be adequate for module-to-module connection and still provide practical limits on constructability.

A single connector may not be adequate for side-to-side or end-to-end connection. It is recommended that such connection scenarios be precluded as a part of operations procedures.

It is recommended that the applicability of the design load envelope given in Reference 1 be established for use in side-to-side connections and the connection of multiple barge modules.

2.3.1 Concept Development Modifications

2.3.2.1 Fabrication Tolerances

It is strongly recommended that the effects of barge fabrication and connector assembly frame placement tolerances be decoupled from the connection system through deliberate design at the interface of the barge module support structure and assembly support frames. This can be most readily accomplished by modifying the overall concept design so that barge module-to-module contact occurs at the connector assembly face plates. This will result in an enhanced connection concept that is of minimum weight, less complicated in design and easier to activate in at-sea conditions. The resulting enhanced concept is also closest to the initial NFESC proposed concept of Reference 2.

2.3.2.2 Cable

It is recommended that connection cable lengths be as long as possible, consistent with barge module and storage requirements, so as to minimize snap load effects during connection operations.

2.3.2.3 Stabbing Pin

The stabbing pin length should be as short as possible. This may not reduce the weight of the stabbing pin but it will significantly reduce the weight and cost of the connector stabbing frame and barge module support structure.

It is recommended that the stabbing pin nose section be strengthened to preclude crushing of the stabbing pin nose section under shearing loads. The recommended alternative for achieving this is to increase the wall thickness of the nose section to at lease 7/8 inch. The nose section, at a minimum, should be 50 ksi material.

2.3.2.4 Assembly Frame

It is recommended that the connector assembly frame be modified in the following ways:

- specify high-strength (Fy=50 ksi minimum) steel throughout. Although high-strength steel could be specified only for the highly stressed areas, it is recommended for all components of the assembly frame as it:

  1) eliminates any mix-up between high-strength and mild steel components,
  2) additional cost is neglibigle (approximately $ 50/ton) and offset by the use of the same material throughout, and
  3) welding specifications can be adequately met.

- the inside diameter of the receptacle casing tubular should be at least 5/8 inch greater than the stabbing pin nose section diameter to ensure the ability to install all stabbing pins into the connector assemblies. This recommendation assumes that barge module-to-module contact occurs at the connector assembly frame face plates; if this assumption is not valid, then a significantly larger diameter receptacle casing will be required along with additional connector components in the connection system.

- add side plates spanning the assembly frame outboard guide slot to minimize deformation induced stress in the assembly frame tubular members under operating loads.

- increase member sizes as recommended in this report, generally for the outboard half of the assembly frame.

- decrease member sizes as recommended in this report, generally for the inboard half of the assembly frame.

2.3.2.5 Barge Module Support Structure

It is recommended that the barge module support structure design include a shimming system or other design that will decouple (see Section 2.3.2.1) the barge construction tolerances from the assembly frame location tolerances so that the stabbing pin / assembly frame mismatch is not dependent upon the barge fabrication. A less expensive and better functioning connection system should result.

2.3.3 Recommended Supplemental Work

Recommended supplemental work for further progressing the engineering development of the ocean barge module connection system is presented in this section.

2.3.3.1 Connection Cable

It is recommended that future work be performed to define maximum snap load magnitudes of the connecting cable during connection operations in SS3 (or other as specified) environments. Such work, at a minimum, should involve the parametric nonlinear dynamic motions analysis of two barge modules connected by cables. The analyses should establish the cable lengths, barge positions and environmental conditions for which cable snap loading is most probable and/or most severe and establish the cable design requirements necessary to perform a safe connection.

2.3.3.2 Stabbing Pin

Minimization of the stabbing pin length should be a major design objective as the pin length affects the weight and cost of other associated connection system structure. A more precise stabbing pin size and impact load resistance requirement should be determined based on the latest available model basin tests and design requirements.

Detailed finite element analyses should be undertaken for the stabbing pin nose section under design operating conditions. Both strength and fatigue loading should be analyzed and the stabbing pin design further developed in order to attain the desirable system strength and life cycle characteristics.

2.3.3.3 Assembly Frame

Detailed finite element analyses should be undertaken for the assembly frame casing receptacles, nearby connecting structure, the guillotine plates and highly loading tubular joints under design operating conditions. Less detailed finite element analyses should be undertaken for the remaining frame structure. Both strength and fatigue loading should be analyzed and the stabbing pin design further developed in order to attain the desirable system strength and life cycle characteristics.

2.3.3.4 Barge Module Support Structure

The initial barge module support structure design development presented here should be merged with the overall barge module structure design and an integrated, cost-efficient overall structure design developed. This work should include a finite element analysis of the entire structure for design operating strength and fatigue loading in order to further develop the design with respect to the desirable system strength and life cycle characteristics.

A shimming system or other design detail should be developed in detail for assessment by manufacturers for fabricability and achievability of desired tolerances within practical weight, cost and schedule parameters.

2.3.3.5 Back-Up Connector System Development

The NFESC proposed barge module connection system was shown to be viable with some modifications to several components. Although the development work performed to-date is:

1) based on limited motions data for the end-to-end connection of two modules and
2) providing upper-bound snap loads and component member preliminary designs,

this work does not ensure that:

1) the module weight increase and the buoyancy losses are minimized
2) the constructed costs are minimized
3) the connection/disconnection and repair/replacement options for the connector assembly are optimized.

Thus, it is recommended that while further development work is performed on the NFESC concept, a less extensive effort be made to develop a "back-up" connection system. Such an effort will also provide comparative data for assessing the "primary" and "back-up" concepts as to:

1) connection in SS3,
2) operation/resistance in SS5,
3) weight and payload,
4) inspection, repair and replacement, and
5) life cycle costs.

3. SPECIAL CONSIDERATIONS

3.1 FABRICATION TOLERANCES

Successfully connecting barge modules in open sea conditions depends on a number of parameters. One important parameter is the tolerances to which the various connection components are manufactured and the effect of these tolerances on the overall connection design and operation.

This section discusses the fabrication tolerances recommended for the design of the stabbing pin, connector assembly frame, and overall barge structure and their effect on the overall design and operation of the connection system for both of the above contact options.

The specification of fabrication tolerances for the barge module structure and the connection system components is highly dependent on the barge module-to-module contact assumed in the connection design. One of two barge contact options are presently assumed, namely:

- Contact Option 1: barge module-to-module contact occurs at the face plate of the connector assembly frames (i.e., assembly frame contact).
- Contact Option 2: barge module-to-module contact occurs at the barge module surfaces (i.e., barge surface contact)

Section 3.2 discusses the advantages and disadvantages of both of the above options. In that section, "Contact Option 1" is recommended mainly because of its advantages with respect to overall barge fabrication tolerances and its inherent simplification of the connection system design.

3.1.1 Stabbing Pin

Specified fabrication tolerances for the stabbing pin should be the same regardless of the contact option selected. Differences due to contact option will be accounted for in actual design sizes but even these differences should be minimal for the stabbing pin design.

TR-02 (Reference 3, Table 3.1-1) provides fabrication tolerances for the stabbing pin manufacture that are compatible with industry standards and that should be readily obtainable in shop fabrication. These are summarized as:

- Pin diameter tolerance +/- 1/32"
- Pin orientation tolerance (i.e., straightness) +/- 0.4 deg

Assuming the above tolerances are appropriate and that the applicable connection distance between inboard edges of the connector assembly frame receptacle casings is about 18 inches, the maximum positional error, e_{max}, at the critical edge of the stabbing pin tubular is:

$$e_{max} = 18'' \tan(0.4) / 2 + 1/32'' = 0.094''$$

Note that the orientational component of the above calculation assumes that the pin is bowed over a length of 18 inches with the maximum positional error occurring at midspan.

The above discussion assumes that positional error due to the total length of the stabbing pin does not apply to the connection system design. This is appropriate if there is enough flexibility in the system to allow such misalignment. Assuming a 72 inch long stabbing pin, the misalignment should be no more than 0.53 inches. Therefore, the connector assembly frame rubber wheel assemblies should be designed to accommodate this misalignment under load so that this potential misalignment may be neglected in the design. This applies regardless of contact option.

3.1.2 Connector Assembly Frame

Specified fabrication tolerances for the connector assembly frame should be the same regardless of the contact option selected. Differences due to contact option will be accounted for in actual design sizes and additional connection components. For "Contact Option 2" (i.e., barge surface contact), the receptacle casing diameter will have to be increased, perhaps substantially, to accept a more widely varying stabbing pin position. Depending on the relative diameters of the stabbing pin and assembly frame receptacle casing, additional connection components will have to be provided to eliminate the gaps inherent in this connection.

TR-02 (Reference 3, Table 3.1-1) provides fabrication tolerances for the connector assembly frame that are compatible with industry standards and that should be readily obtainable in shop fabrication. These are summarized as:

- Receptacle casing diameter tolerance +/- 1/32"
- Receptacle casing placement tolerance +/- 1/8"
- Receptacle casing orientation tolerance +/- 0.4 deg
- Placement within module, transverse +/- 1/4"
- Placement within module, elevation +/- 1/8"
- Orientation within module, vertical axis +/- 0.2 deg
- Orientation within module, horizontal axis +/- 0.4 deg

Assuming the above tolerances are appropriate and that the applicable connection distance between inboard edges of the connector assembly frame receptacle casings is about 18 inches, the maximum positional error, e_{max}, at the critical edge of the stabbing pin tubular is:

$$\begin{aligned} e_{max} &= 1/32'' + 1/8'' + 9'' \tan(0.4) \\ &+ 9'' \tan[\,(0.4^2 + 0.2^2)^{1/2}\,] + (0.25''^2 + 0.125''^2)^{1/2} \\ &= 0.569'' \end{aligned}$$

Note that the above placement tolerances are the major contributors to this positional error. This strongly suggests decoupling this tolerance component effect from the connection system design. Connection Option 1 assumes such decoupling; for this option the positional error reduces to 0.219".

3.1.3 Barge Module

Specified fabrication tolerances for the overall barge will depend on the contact option selected. For Contact Option 1 (i.e., assembly frame contact), most of the barge tolerance effects can be decoupled from the connection system through the use of permanent adjustments provided during barge construction, a relatively simple task. For Contact Option 2 (i.e., barge surface contact), this decoupling must occur through the use of secondary shimming systems in the connectors themselves, which are applied at sea for each use. This is a much more difficult objective to achieve.

TR-02 (Reference 3, Table 3.1-1) provides fabrication tolerances for the overall barge module that are compatible with industry standards and that should be readily obtainable in a shipyard. These are summarized as:

- Module dimensions, length +/- 1/2"
- Module dimensions, width +/- 3/8"
- Module dimensions, height +/- 1/8"
- Module differences, lengths +/- 1/2"
- Module differences, widths +/- 3/8"
- Module differences, heights +/- 1/8"

The module length dimension and module width difference tolerances affect side-to-side connections whereas module width dimension and module length difference tolerances affect end-to-end connections. The height tolerances are applicable to both types of connection. Thus, assuming no decoupling of barge tolerances from the connection system, the maximum positional error, e_{max}, at the connector stabbing pin centerline is:

- End-to-end connections:

$$e_{max} = (0.375''^2 + 0.125''^2)^{1/2} + (0.250''^2 + 0.125''^2)^{1/2} = 0.675''$$

- Side-to-side connections:

$$e_{max} = (0.500''^2 + 0.125''^2)^{1/2} + (0.188''^2 + 0.125''^2)^{1/2} = 0.741''$$

The side-to-side connection is more critical with respect to standard barge fabrication tolerances. However, this consideration is secondary since the maximum positional error is relatively large in both cases.

The magnitude of both numbers illustrates the importance of reducing the effect of these tolerances on the connection system design. The implications on design for the two contact options are:

- Contact Option 1 (assembly frame contact): provide a 3/4 inch allowance for placement of the connector barge module support structure and theoretical location of the assembly frames during barge construction. A total positional error of 1/8" relative to other assembly frames should be achievable in the shipyard.

- Contact Option 2 (barge surface contact): the connector assembly casing receptacle diameter must be increased an additional 1.5" and the associated connection gaps eliminated through the use of additional shimming systems on each connector.

3.1.4 Cumulative Tolerances

The positional errors determined in previous sections are accumulated in this section (see Table 3.1-1) to arrive at appropriate design values for each contact option. The positional error represents the required minimum design difference in stabbing pin and assembly frame receptacle pin radius. Contact Option 1 assumes decoupling of most of the barge fabrication tolerance during barge construction; Contact Option 2 assumes the presence of additional systems to compensate for these tolerances.

From the standpoint of barge fabrication tolerances, Option 1 is preferred because this option allows standard ship-building tolerances to be applied to the overall barge fabrication without requiring overly stringent fabrication tolerances for the connector assembly frame and stabbing pin components or requiring the application of additional mechanical systems to eliminate required gaps in the connection system. This is true even if the shimming system proposed for Contact Option 1 is used in Contact Option 2.

3.1.5 Design and Operation

The cumulative positional errors for both contact options shown in Table 3.2-1 strongly suggest decoupling the effects of most tolerances from the connection design. This is most readily done with Contact Option 1. This contact option has been assumed in the design development presented in the remainder of this report because it eliminates the need for secondary shimming systems in the connector design. The resulting connector design development will be closest to the original NFESC developed concept and will be lighter, less costly and easier to operate, requiring fewer steps to complete a connection.

3.2 BARGE MODULE-TO-MODULE CONTACT

The connection system must resist longitudinal forces due to tension, compression and bending. The tension forces, due to barge tension and bending will be resisted by the connection system stabbing pins as the stabbing pin is the only connection system component capable of resisting tension. Compression forces, however, may be resisted by one of two barge "contact options." The design compression and tension forces should be approximately the same magnitude since they are controlled mainly by barge bending in a vertical plane.

3.2.1 Contact Options

Contact Option 1 is an "assembly frame contact" option. This option presumes that the face plates of all connector assembly frames in a barge module protrude slightly further outboard than any barge structure that may contact adjacent barge structure. Barge-to-barge compression forces are transmitted to each connector assembly frame through the assembly frame face plate and supporting structure.

Contact Option 2 is a "barge surface contact" option. This option presumes that the face plates of all connector assembly frames in a barge module do not protrude beyond any barge structure that is in contact with adjacent barge structure. Barge compression forces are transmitted directly through the barge structure instead of the connector assembly frame.

From an overall design, fabrication and operation point of view, Contact Option 1 would seem preferable since it should result in a lighter and less complex connection system that is easier to operate at sea.

3.2.2 Advantages and Disadvantages

3.2.2.1 Contact Option 1

The main advantage of Contact Option 1 over Contact Option 2 is that the effect of relative tolerances required for barge fabrication can be readily decoupled from the design so that such fabrication tolerances do not adversely affect connection operation. This is possible because the compression loads are taken through the assembly frame where this decoupling occurs. Without this decoupling, additional gaps must be provided between the connector stabbing pins and assembly frame receptacle casings to ensure that will ensure that all connectors can be activated. Such gaps will have to be eliminated by providing additional shimming capability at sea, further complicating the connection design and its operation. These tolerance implications are discussed further in Section 3.2.

3.2.2.2 Contact Option 2

The main advantage of Contact Option 2 over Contact Option 1 would appear to be the direct transfer of compression load from one barge module to another. However, this advantage is relatively minimal since the design compression load is not likely to differ much from the design tension load. Since the connector assembly frame must be designed for the design tension load for both contact options and buckling does not control the design of the assembly frame structure, there will be at best a minor savings in assembly frame and associated support structure weight. In fact, Contact Option 2 may require added structure in the barge itself to resist the compression contact loads that will outweigh any savings in connector system structure.

3.3 SIDE-TO-SIDE VERSUS END-TO-END CONNECTIONS

Previously, the connection system concept was developed based on its application to end-to-end connections of barge modules. The side-to-side connection of modules was assumed covered by default. Obviously, this assumption is valid if the design loads for a side-to-side connection are less than those for end-to-end connections. This needs to be demonstrated by additional motions analyses studies for all viable barge and associated connection system configurations. The possibility of missing connectors due to connection/disconnection or repair/replacement also needs to be considered when validating the assumed connection design envelopes.

3.3.1 Barge Configurations

Four barge configurations (Figure 3.3-1) are presently assumed. These are:

- Configuration 1: Two (2) barge modules are connected end-to-end. This configuration requires two (2) end-to-end connectors and no (0) side-to-side connectors.

- Configuration 2: Three (3) barge modules are connected end-to-end. This configuration requires four (4) end-to-end connectors and no (0) side-to-side connectors.

- Configuration 3: Six (2) barge modules are connected end-to-end and side-to-side in a 2 module by 3 module configuration. This configuration requires eight (8) end-to-end connectors and two (2) side-to-side connectors.

- Configuration 4: Six (2) barge modules are connected end-to-end and side-to-side in a 2 module by 3 staggered module configuration. This configuration requires eight (8) end-to-end connectors and two (2) side-to-side connectors.

3.3.2 Connection System Design Envelope

No motions analyses have been performed to-date for the present barge configurations that would determine connection system design envelopes for side-to-side connections. Thus, the connection system design development has proceeded assuming that the end-to-end connection system design envelope is an upper-bound value for all connectors. Reference 1, Section 5 provides this end-to-end connection system design envelope as:

- Maximum vertical bending moment: 2,500 ft-kips
- Maximum vertical shear: 110 kips

This connection system design envelope was used to further develop the connector system assuming two connector assemblies are present. This design envelope is also used to back-calculate the associated connection system design envelopes for all barge configurations presently assumed.

3.3.3 Barge Configuration Maximum Allowable Design Values

Working back from the connection system design envelope for each barge configuration, the maximum allowable design values for each entire configuration were determined. If future motions analyses or model tests determine that higher values are applicable, then either the connection system components must be strengthened where appropriate or additional connector assemblies must be provided to resist the increased connection system design envelope loads.

3.3.3.1 Configuration 1

Since two connector assemblies are present at the end-to-end connection location, the connection system design envelope directly applies for this configuration, namely:

- Maximum vertical bending moment: 2,500 ft-kips
- Maximum vertical shear: 110 kips

If one connector is missing, the other will probably have to be removed in order to preclude overload of the remaining connector.

3.3.3.2 Configuration 2

Since two connector assemblies also are present at all end-to-end connection locations, the connection system design envelope directly applies for this configuration, namely:

- Maximum vertical bending moment: 2,500 ft-kips
- Maximum vertical shear: 110 kips

If one connector is missing, the other connector on the same face will probably have to be removed in order to preclude overload of the remaining connector.

3.3.3.3 Configuration 3

Four connector assemblies are present at all end-to-end connection locations and two connector assemblies are present at the side-to-side connection. The two connection system design envelopes are therefore:

For end-to-end connections:

- Maximum vertical bending moment: 5,000 ft-kips
- Maximum vertical shear: 220 kips

For side-to-side connections:

- Maximum vertical bending moment: 2,500 ft-kips
- Maximum vertical shear: 110 kips

If one side-to-side connector is missing, the other side-to-side connector will probably have to be removed in order to preclude overload of the remaining connector. Alternatively, a spare connector could be placed in the center side-to-side slot although added prying forces on the barge will be present.

3.3.3.4 Configuration 4

Four connector assemblies are present at some end-to-end connection locations and two are present at others. Two connector assemblies are present at the side-to-side connection. The two connection system design envelopes are therefore:

For end-to-end connections at barge midspan:

- Maximum vertical bending moment: 5,000 ft-kips

- Maximum vertical shear: 220 kips

For other end-to-end connections except at barge midspan:

- Maximum vertical bending moment: 2,500 ft-kips
- Maximum vertical shear: 110 kips

For side-to-side connections:

- Maximum vertical bending moment: 2,500 ft-kips
- Maximum vertical shear: 110 kips

Note that barge module torsional moments on the end module may be of more importance for this configuration.

If one side-to-side connector is missing, the other side-to-side connector will probably have to be removed in order to preclude overload of the remaining connector. This also applies to the end-to-end connectors on the extended single barge module.

ITEM	POSITIONAL ERROR (inches)			
	Contact Option 1 (Assembly Frame Contact)		Contact Option 2 (Barge Surface Contact)	
	Decoupled	Not Decoupled	Decoupled	Not Decoupled
Stabbing Pin	0.094	0.094	n/a	0.094
Assembly Frame	0.219	0.444	n/a	0.444
Barge	incl.	0.741	n/a	0.741
Total Error	0.313	1.279	n/a	1.279
Req'd D_{casing} - D_{pin}	5/8"	2-5/8"	n/a	2-5/8"

Table 3.1-1
Connection System Positional Error Summary

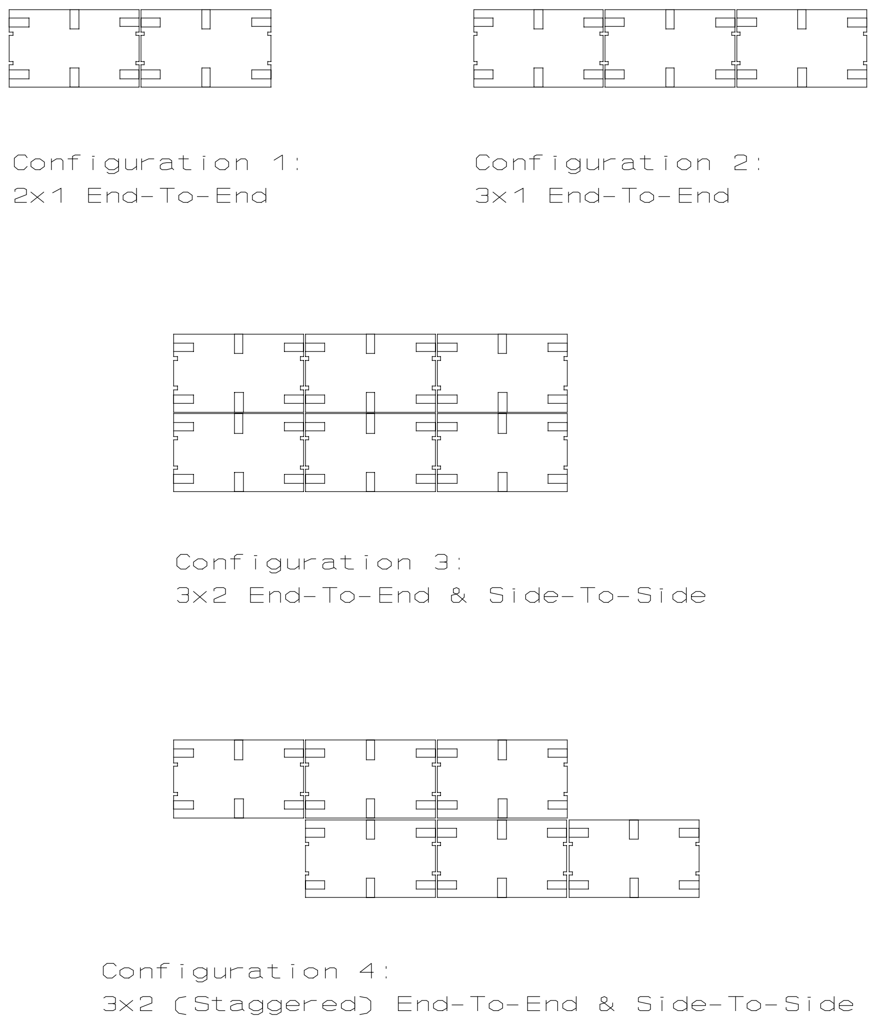


Figure 3.3-1
Barge Configurations

4. REVIEW AND EVALUATION OF ENGINEERING CRITERIA

4.1 GENERAL

This section presents the review and evaluation of NFESC specified functional requirements and engineering design and operational criteria. This review and evaluation was performed for the requirements specified in TM-2067-AMP (Reference 1). The initial review and evaluation was performed in September 1995 as documented in Reference 3 and was further modified during subsequent tasks as the connection system development progressed.

4.1.1 Objectives

NFESC's primary objective is the development of a connection system for the rigid connection of modules in open sea environments that ensures structural integrity and reliability of the system, provides for the safety of personnel, and provides relatively easy and quick connections, all within target weight and cost parameters.

Accomplishing this primary objective will also ensure meeting other secondary objectives, namely:

- extending present rigid connection capability from Sea State 1 to Sea State 3.
- allowing connection without causing unusual and infeasible logistic burdens.
- expanding the weather window for sealift operations.
- providing a database for the future development of the connection system.

4.1.2 Scope

This section presents the review and evaluation of NFESC's requirements for the module connection system and defines the applicable engineering design criteria that can be used in the review and evaluation of the government concept for module connection. Sections 4.2 and 4.3 discuss functional requirements and the engineering criteria, respectively.

4.2 FUNCTIONAL REQUIREMENTS

4.2.1 Overview

The NFESC stated objectives and goals are reasonable but some of the requirements associated with system compatibility, structural integrity, operability, reliability and safety cannot be achieved without tradeoffs.

Some of the concerns in achieving desirable tradeoffs are as follows:

- Any mechanical system can fail, and will require inspection, maintenance and possibly repair. Thus, the NFESC defined "simple system without problems (i.e., no concern)" should be viewed as a desirable goal. The desirability of one system over another can be evaluated by ranking each as to their relative susceptibility to failure.

- NFESC states that generous manufacturing and installation tolerances are required. A tradeoff is essential as very generous tolerances will result in installation and in-service difficulties.

- NFESC requires that moving parts be minimized and remain readily accessible for inspection/replacement. Often readily accessible parts are also susceptible to some degradation of structural integrity and reliability.

Although not specifically stated by NFESC, it is implied that the module is a single compartment and the module connection systems are set inside a casing. Two important considerations for the module and the connector assembly are:

- The connector assembly, including the moving parts, are in a compartment open to water and air. Thus, inspection, maintenance and corrosion prevention becomes an important consideration for disconnection and reconnection of modules.

- The connector assembly can be lifted and repaired or replaced. It is important that a fail/safe operating system is built into design to preclude loss of module structural integrity (e.g., movement of the lever to advance the stabbing pin can be prevented unless the deck connection bar over the assembly is in place).

The review and evaluation results are summarized on Table 4.2-1 and further discussed in the following subsections.

4.2.2 System Compatibility

System compatibility requirements listed, including the configuration and the components remaining within the envelope, are reasonable and achievable. Although the total weight of the module will increase with the magnitude of the loads to be transferred into the module, the overall weight should remain within the lift capacity.

4.2.3 Producibility

To ensure that the modules are mass produced and maintained at low cost, NFESC requires that the tolerances for manufacturing and repair be not too tight and the module and connection system design lives and repair cycles be compatible.

Although the requirements are valid, low cost, low maintenance and loose tolerances are not directly compatible with (1) producibility, (2) operability, (3) integrity and (4) reliability. A tradeoff is necessary to ensure that the defined tolerances meet the four parameters listed above.

4.2.4 Operability

NFESC requires that each module connection be achievable in an open sea environment at Sea State 3 within 30 minutes without the use of specialized equipment. It is stated that no more than two (2) tender boats per line be used and the connection system does not result in appreciable reduction in barge capacity.

The requirements as specified are achievable, yet require careful scrutiny. Some of the variables affecting the operability and not specifically addressed are:

- loose tolerances for manufacturing and connection ease will complicate the load transfer system, causing degradation in integrity and reliability as well as increasing steel weight. This subject is discussed further in Sections 3 and 5 of this report.

- each module will be slightly different in weight and buoyancy, resulting in the modules to be connected having different drafts. The differential draft is additive to the connection system tolerances built-in during manufacturing.

- modules are susceptible to damage and flooding. Similarly, the deck loads on the connected system (i.e., modules forming a barge) will not be uniform, causing uneven deformations. Thus, disengagement may not be readily achievable.

4.2.5 Safety

The desired objectives of ensuring that the connection system has the maximum safety in use and minimizes hazards in case of failure are reasonable and achievable. Similarly, limiting the use of heavy hardware to minimize personnel risks is achievable.

4.2.6 Structural Integrity

In addition to readily achieving the connection in Sea State 3, the connection system should resist the extreme loads associated with a Sea State 5 storm. NFESC requires the use of a simple design that avoids many moving parts and mechanical functions to ensure structural integrity.

The requirement is reasonable and achievable. However, the connection system subjected to cyclic loads in a marine environment will exhibit degradation in integrity. It is necessary to specify both design life and the criteria for disengagement to ensure compatibility in life cycles and minimize inspection and repair costs.

4.2.7 Reliability

NFESC stated requirements to enhance reliability by developing a simple connection system with a minimum number of moving parts and without intricate mechanical systems are reasonable and achievable. However, it is not reasonable to expect that such components will be "unaffected by corrosion, dirt and neglect."

Since the connection system is subjected to a corrosive ocean environment, it needs to be protected by the use of coatings as well as sacrificial anodes. Coatings and anodes will require inspection and maintenance.

A connection system designed to resist Sea State 5 loads may experience larger loads due to impact damage and flooding. If nonlinear deformation of the connectors occurs disengaging the connection may not be possible. Different loading patterns from one module to another can cause deformations and frictional resistance that may also prevent disengagement of the connection system.

4.3 ENGINEERING DESIGN CRITERIA

Although the work scope for this project is limited to the further development of the connection system, it is necessary to address both the connection system and the module supporting each of the six connection systems on board. The following sections summarize the applicable design criteria for the module and the connection system.

4.3.1 Environmental Criteria

Three distinct environmental criteria are necessary to define the applicable open sea environment:

4.3.1.1 Connection

The NFESC stated objective of the ability to connect in Sea State 3 is valid. However, relative motions between the connection systems should be defined for:

(a) End-to-end connection between two modules for head seas.

(b) End-to-end connection between a rigid two-module unit and a single module for head seas.

(c) Side-to-side connection between two modules for beam seas.

(d) Side-to-side connection between a two rigid three-module units for beam seas.

The review of the design environment and associated motions will provide a better understanding of the connection system motions/loads as a function of storm (environment) direction and module configuration.

4.3.1.2 In-Service Operation

The NFESC stated need to ensure the integrity of the system when the rigid modules are subjected to a Sea State 5 environment is valid. However, other potential environmental conditions need to be considered:

(a) Flooding of a module and loadings associated with an environment less severe than Sea State 5. Perhaps, Sea State 4 is appropriate for this condition until corrective measures are taken.

(b) Impact damage to a module and connection system and loadings associated with an environment less severe than Sea State 5. Perhaps, Sea State 4 is appropriate for this condition until corrective measures are taken.

4.3.1.3 Disconnection

No information is provided on disconnection. It is assumed that Sea State 3 is appropriate for disconnection. However, other conditions requiring definition are:

(a) Disconnection of one connection and removal of the connector assembly. Environment associated with Sea State 3 is considered appropriate. Thus, a single connection will have to transmit the loads associated with this environment from one module to another. However, this scenario is not applicable to a barge formed by a single row of modules connected end-to-end as the remaining connector would be incapable of resisting the resulting barge module torsional moments.

(b) Compatible functional and environmental loads on the other modules if one module is to be disconnected and replaced.

4.3.2 Design Criteria

To ensure structural integrity and reliability of the module and connection system and to construct it cost effectively, the module and component design criteria should be compatible. Some of the applicable items are:

4.3.2.1 Design Life

Although a specific design life is not defined, it is desirable that the design life for the module be compatible with the life cycle of primary connection system components. To ensure a cost effective system, the design life may be taken as 20 years.

4.3.2.2 Configuration

The connection system and its components should meet the following requirements:

- remain within the module envelope.
- require the use of few moving parts.
- retain simplicity in design.
- allow effective load transfer.
- allow quick and easy removal and replacement of components.
- require minimum inspection and maintenance.
- avoid the use of specialized and heavy hardware.
- eliminate the need for the crew to take risks.

4.3.2.3 Applied Loads

Applied environmental and functional loads shall be generated to ensure both compatibility with each other and to provide representative distribution. The connection system should maintain its integrity when subjected to connection, in-service and disconnection (items 4.3.1.1, 4.3.1.2 and 4.3.1.3) loads.

4.3.2.4 Material

Module plate and stiffening material may be assumed to be mild steel with a yield strength range of 36 to 42 ksi. However, the connection system and the support structure shall be assumed to be high strength steel with a yield stress range of 50 to 55 ksi.

The movable connection system component (i.e., "stabbing pin") shall be assumed to be coated with monel sheathing to both protect it against corrosion and to reduce friction between moving parts.

4.3.2.5 Analysis and Design

Computer models of the developed connection system shall be sufficiently detailed, including compatible loading application, in order to determine accurate stress distributions.

The connection system and the supporting structure distributing the loads onto the module shall be analyzed and designed to meet several sets of compatible extreme load conditions. The connection system and supporting structure components shall have adequate reserve capacity to allow redistribution of unexpected impact loads. Design details shall avoid high stress concentrations and potential fatigue problems.

4.3.2.6 Cathodic Protection

The module and the connection system shall be provided with sacrificial anodes to meet the design life and structural integrity requirements.

4.3.2.7 Module and Connection System Weight

The overall steel and appurtenances weight (i.e., including sacrificial anodes) shall be limited to about 30 tons to ensure that crane lifting capacities are not exceeded.

4.3.3 Construction Criteria

The module and connection system construction criteria should allow cost effective construction of the components and still facilitate connection of the modules and ensure structural integrity of the connected system.

To provide a tradeoff between very loose and very tight tolerances, the following conditions should be considered and a thorough fabrication tolerances study performed to determine the tolerances compatible with industry standards on construction.

4.3.3.1 Barge-to-Barge Contact

Overall barge dimensions (i.e., tolerances on length, width and depth) as well as deviations from a straight line should be considered for the adequacy of end-to-end and side-to-side contacts.

4.3.3.2 Connection-to-Connection Contact

Unless specifically decoupled, the connection system tolerances should be added to module fabrication tolerances. Cumulative module and connection system tolerances between the stabbing pin and the receptacle casing are excessive and undesirable. Thus, the connection system casing should be located based on theoretical module dimensions and decoupled from module tolerances.

4.3.3.3 Other Considerations

The connection system tolerances computed based on connector assembly location, orientation and the location and orientation of the stabbing pin and receptacle casing should be considered in conjunction with variations in weight and volume from one module to another. Thus, such draft differentials should be incorporated into connection system tolerances.

4.3.4 Operations Criteria

Environmental criteria for connection, in-service performance and disconnection is defined in Section 4.1. In addition, the connection system and module interchangeability should be further considered for:

4.3.4.1 Intact Condition Connection and Operation

The tolerances, applicable environment and loads considered for connection and in-service operation shall meet the restrictive criteria established for standard connection and in-service operational conditions.

4.3.4.2 Damaged Condition Connection and Operation

Connection component (i.e., the stabbing pin or module connector assembly) may be damaged during connection work or in-service. Considering overall system efficiency, the following may be considered acceptable:

- Damaged connector assembly forcibly secured even if the steps taken preclude normal disconnection of the assembly at a later time (i.e., sacrifice the assembly and replace it later).

- Connector assembly damaged during in-service operation is removed and replaced. Less severe Sea State 4 loads are applicable to the system during this limited duration replacement period.

4.3.5 Rules, Regulations and Philosophy

The rules, regulations and philosophy applicable to the ocean barge module connection system shall allow effective design, construction, connection and in-service performance of the system. Thus, while the structural integrity of the system is maintained and its reliability optimized, the system shall remain easy to construct and mass produce at a reasonable cost.

A list of applicable regulations and standards shall be prepared and referenced wherever appropriate.

4.3.6 Recommended Design Basis

The functional requirements listed in Sections 4.2.2 through 4.2.7 and the engineering design criteria listed in Sections 4.3.1 through 4.3.5 provide the basis for the development, analysis and design of the connection system. The established requirements and engineering design criteria constitute the "recommended design basis" and shall be used in the following project tasks, including the review and evaluation of government concept (Task 30) and the preliminary development of the connection system layout and the analysis and design of the connection and connection support systems (Tasks 40, 50 and 60).

Table 4.3-1 presents a checklist used in subsequent development tasks.

Table 4.2-1 - Summary of Comments on Requirements

FUNCTION PARAMETERS	a. SYSTEM COMPATIBILITY	b. PRODUCIBILITY	c. OPERABILITY	d. SAFETY	e. STRUCTURAL INTEGRITY	f. RELIABILITY
1. GENERAL	1.1 Close to box configuration 1.2 Modifications to design: Minimum	1.1 Tolerances for manufacturing & repair should not be tight. 1.2 Compatible module and connection system design lives and repair cycles.	1.1 System req'ts. yet to be fully specified. 1.2 Ability to join modules at diff. drafts in SS3. 1.3 Tolerances must be loose.	1.1 Conn. System to have MAX. safety in use & MINimize hazards in case of a failure. 1.2 Crew NOT to handle heavy hardware or required to take risks.	1.1 Connection to distribute the load. 1.2 Simple design for no concern over mechanical functions.	1.1 See item e1.2. Some concern.. ALWAYS. 1.2 No unique tools or military assets. 1.3 No intricate mechanical sys.
2. SPECIFIC	2.1 All components within the envelope. 2.2 Total weight not to exceed lift capacity.	2.1 Low cost, low maintenance and suitable for mass production.	2.1 Connections installable in 30 minutes. 2.2 No appreciable reduction in barge capacity due to conn. sys. 2.3 No more than 2 tender boats per line.		2.1 Resist loads at Sea State 5. 2.2 Prefer primary internal structure for load transfer (i.e., not discrete connectors).	2.1 Unaffected by corrosion, dirt and neglect. 2.2 Minimize moving parts & maintenance. 2.3 Not to be vulnerable to impact damage. 2.4 Moving parts be accessible and easily replaced.
3.COMMENTS	■ Information on Navy's module design not given. Required for the project.	■ Low cost, low maintenance and loose tolerances are not directly compatible with: ■ integrity ■ reliability ■ operability	■ Some reduction of load carrying capacity will occur (see item c2.2). ■ WT bulkheads needed for safety, load capacity and disengagement.		■ Mechanical connections do cause concern. (see item e1.2.) Design should minimize concern.	■ Items f2.1, f2.3 and f2.5 are difficult to achieve. ■ CP adds to the weight & requires inspection.

Table 4.3-1 Engineering Criteria - Summary Checklist

PARAMETER	CRITERIA	CHECKLIST *Yes/No Action*	COMMENTS
REQUIREMENTS			
System Compatibility	Remain within envelope	Yes None	System compatibility
	Don't exceed lift capacity	Yes None	achieved, monitor weight
Producibility	Compatible life cycles	Yes None	Tradeoff tolerances
	Loose tolerances	No Tradeoff	loose/tight for integrity and
	Low cost/maintenance	Yes None	operation
Operability	Connect modules in SS3	Yes None	Add damaged condition &
	@ diff. drafts in 30 min	Yes Disconnect	disconnection
Safety	MAX safety/MIN hazards	Yes None	Max/Min goals achievable
	No risk to CREW	Yes None	
			Optimize load path
Structural Integrity	Simple design/load path	Yes None	Damaged cond. capacity
	Resist SS5 loads	Yes None	
			D.I.R.T.
Reliability	No concern mech. func.	No Assess	Design, Inspection &
	No unique tools	Yes None	Redundancy Triangle
	No damage/distortions	No Review	to be built-in
	Removable parts	Yes None	
ENVIRONMENT			
Connection	End-to-end	Yes ≥ 2 modules	Loads available only for
	Side-to-side	Yes ≥ 2 modules	two-module connection
In-Service	Flooded module	No Assess	Integrity for SS4?
	Damaged connection	No Assess	Integrity for SS4?
Disconnection	Removal of assembly	No Assess	Attempt @ SS3 or less
	Removal of module	No Assess	Attempt @ SS3 or less
DESIGN			
Life	Comparable life cycle	Yes Assume	Set design life: 20 yrs.
Configuration	Dev. effective support sys	Yes Develop	Develop effective load path
Loads	Multiple connection sys	No Estimate	Extrapolate test basin data
Material	Mild & high strength steel	No Assume	Use 42 ksi & 50 ksi steel
Modeling	Need adequate refinement	Yes Develop	Develop computer model
Analysis/Design	Pre- and in-service	Yes Perform	Perform analysis/design
Cathodic Protection	For design life	Yes Estimate	Provide sacrificial anodes
Weight Monitoring	Remain within lift capacity	Yes Essential	Estimate module and connection sys. weights
CONSTRUCTION			
Quality/Tolerances	Quality mass production	Yes Tradeoff	Balance loose/tight tol.
Cost	Maintain low cost	Yes Tradeoff	Optimize for low cost
OPERATION			
Intact	Intact connection/in service	Yes Assess	Assess other scenarios
Damaged	Damaged operation	No Assess	Consider damaged cond.
RULES/STANDARDS	List applicable rules, standards & regulations	No Define	List applicable standards

5. REVIEW AND EVALUATION OF NFESC CONCEPT

5.1 GENERAL

This section presents the review and evaluation of NFESC connection concept. This review and evaluation was performed for the requirements specified in TM-2067-AMP (Reference 1). The initial review and evaluation was performed in September and October 1995 as documented in Reference 4 and was further modified during subsequent tasks as the connection development progressed.

5.1.1 Objectives

NFESC's primary objective is the development of a connection system for the rigid connection of modules in open sea environments which will ensure structural integrity and reliability of the system, provide for the safety of personnel, and provide easy and quick connection, all within target weight and cost parameters.

Accomplishing this primary objective also meets other secondary objectives, namely:

- extending current rigid connection capability from Sea State 1 to Sea State 3.
- allowing connection without causing unusual and infeasible logistic burdens.
- expanding the weather window for sealift operations.
- providing a database for the future development of the connection system.

The objective of this section is to document the results of the review and evaluation of the NFESC selected concept documented in TM-2067-AMP (Reference 1).

5.1.2 Scope

The scope of the review and evaluation of the NFESC selected concept includes a number of parameters grouped into two categories:

(1) Compatibility of concept with functional requirements and engineering criteria.

(2) Further review of potential problem areas and identification of applicable solutions.

The review and evaluation work scope is slightly different than the work scope defined in the proposal submitted to the government. Originally it was assumed that several concepts would be provided for review and evaluation. Each system component/function would then have been compared and ranked as a basis for selecting one concept over another. Since the selected concept was provided, this report does not include an economic or technical ranking.

5.1.4 Conclusions

The developed NFESC concept, covering the stabbing pin and the connector assembly, is generally suitable for end-to-end and side-to-side connection of barge modules in Sea State 3 and can resist the extreme environments associated with Sea State 5.

Cost effective producibility (i.e., constructability) and operability (i.e., connection) dictate loose tolerances while the system integrity (i.e., load transfers) requires tight tolerances. To ensure that both of these objectives are met, the connector assembly design and associated construction and installation tolerances should be decoupled from barge module construction tolerances.

A single guillotine proposed to lock the stabbing pin is practical; however, the load transfer from the stabbing pin into the connector assembly is not practical within reasonable construction tolerances and deformation limits. Thus, a second guillotine to effectively transfer the shear loads was considered. This option was rejected as the guillotines could not provide an effective load path.

Thus, the only viable option was to provide the stabbing pin and the receptacle casing with sufficiently tight tolerances (i.e., for shear load transfer) by decoupling the barge module and assembly frame fabrication tolerance effects from the overall connection system design.

The NFESC concept development is limited to the connector assembly. The support structure for load transfer from connector assembly into the barge module needs to be developed. Further discussion on proposed revisions to the connector assembly and the new support system is performed in Task 40 and reported in Technical Report TR-03.

Sections 5.2 and 5.3 of this document discuss the review and evaluation results.

5.2 COMPATIBILITY WITH REQUIREMENTS AND CRITERIA

5.2.1 Functional Requirements

The functional requirements stipulated by NFESC and discussed in Technical Report TR-01 are "Overview," "System Compatibility," "Producibility," "Operability," "Safety," "Structural Integrity" and "Reliability."

The stated functional requirements associated with system compatibility, structural integrity, operability, reliability and safety are achievable but will require tradeoffs among incompatible requirements. The NFESC concept and its compatibility with the functional requirements is presented in terms of "primary" and "secondary" considerations.

5.2.1.1 Primary Considerations

Considerations identified as "primary" indicate that the NFESC concept may not meet the requirements and may need to be modified. These considerations are:

(a) Construction and Installation Tolerances (Producibility and Operability)

NFESC requires generous manufacturing and installation tolerances. A tradeoff is essential as very generous tolerances will result in installation and in-service difficulties.

Constructed barge modules will deviate from their theoretical dimensions, thereby affecting module-to-module contact and the insertion and engagement of the stabbing pins. The cumulative effect of dimensional tolerances requires substantial dimensional flexibility between the stabbing pin and the receptacle casing.

(b) Disconnection and Retraction of the Stabbing Pin (Operability and Reliability)

NFESC requires that the stabbing pin is readily disconnected and retracted either to repair/replace the connector assembly or to disconnect the barge modules in preparation for their deactivation. Differences in module deformations at each connector assembly due to differences in loading and corrosion may make the retraction of the stabbing pin difficult.

(c) Stabbing Pin to Assembly Load Transfer System (Structural Integrity)

NFESC requires that the connection system be simple, function reliably and provide connection and structural integrity. The stabbing pin concept illustrated in the developed NFESC concept requires further scrutiny in two areas: (1) impact loading prior to connection, and (2) load transfer from the connected stabbing pin into the connector assembly.

Impact load can be minimized by providing a relatively flexible spring attachment to the stabbing pin. The proposed single guillotine will not provide a shear load transfer mechanism between connected modules unless the tolerances are very tight or large deformations are allowed prior to shear load transfer. Since both alternatives are not practical, an alternative option was considered. This option , requiring the use of a second guillotine to provide for a more effective load transfer, was rejected as the guillotines could not offer effective load paths.

5.2.1.2 Secondary Considerations

Considerations identified as "secondary" indicate that the NFESC concept is workable as-is but may not necessarily meet some of the requirements as well as the others. These considerations are:

(a) NFESC defined "simple system without problems (i.e., no concern)" should be viewed as a desirable goal.

Any mechanical system can fail, and will require inspection, maintenance and possibly repair. The desirability of one system over another can be evaluated by ranking each as to their relative susceptibility to failure.

(b) NFESC requires that moving parts be minimized and remain readily accessible for inspection/replacement.

Often readily accessible parts are also susceptible to some degradation of structural integrity and reliability.

5.2.2 Engineering Design Criteria

The following engineering design criteria were reviewed and found compatible with NFESC stated requirements and the connector assembly concept.

5.2.2.1 Environmental Criteria

Proposed environmental criteria for connection and disconnection in Sea State 3 are reasonable and achievable. Applicable environmental criteria for in-service structural integrity when subjected to ocean environments associated with Sea State 5 are also reasonable and achievable.

5.2.2.2 Design Criteria

Design criteria for the connector assembly should define a viable combination of applicable environmental and functional loads. Produced stresses due to differential deformation of modules when subjected to different functional loads will be combined with extreme environmental loads.

Design criteria should also address unbalanced loads due to special conditions, such as removal of a connector assembly. For a two-module barge connected end-to-end removal of one connector assembly is not viable. Since the two stabbing pins in one connector assembly cannot practically resist the design bending loads, removal of one connector assembly dictates disconnection and retraction of the two stabbing pins in the other connector assembly.

5.2.2.3 Construction Criteria

Construction criteria, including material specifications, construction tolerances and welding procedures, should lead to cost effective construction of quality barge modules and connector assemblies. Design criteria should be compatible with typical industry construction standards.

5.2.2.4 Others

Operations criteria, rules and regulations and the design philosophy supplement the environmental, design and construction criteria proposed for the connector assembly.

A preliminary Design Basis will be prepared to meet NFESC stated requirements and used in the preliminary design of the connector assembly (i.e., Task 50) and the connector assembly support structure (i.e., Task 60).

5.3 FURTHER REVIEW OF POTENTIAL PROBLEM AREAS

5.3.1 Producibility and Compatible Tolerances

Constructed barge modules will deviate from their theoretical dimensions, thereby affecting module-to-module contact and the insertion and engagement of the stabbing pins. The cumulative effect of dimensional tolerances requires substantial dimensional flexibility between the stabbing pin and the receptacle casing. This is especially true when barge and connector assembly tolerances are not decoupled as a part of the design.

5.3.1.1 Overall Module Configuration

The barge modules should be constructed to industry standards to achieve a high quality cost effective product. Achievable tolerances on 40 ft length, 25 ft width and 8 ft height module will be about +/- 1/2", +/- 3/8", and +/- 1/8", respectively. Considering the:

(1) differences in length from port to starboard and top to bottom, width from forward to aft and top to bottom, and the height from port to starboard and forward to aft, and

(2) deviations in longitudinal and transverse bulkheads along the vertical axis (i.e., in-plane sag) and the horizontal axis (i.e., out-of-plane),

each barge module will deviate from its theoretical dimensions and such deviations can prevent the desirable level of connector fit-up between the modules.

5.3.1.2 Connector Assembly

The connector assembly (i.e., approximately 2 ft wide, 6 ft deep and 6 ft 6 in. high rectangular framing) can be readily constructed in a shop environment to within +/- 1/16". However, six such assemblies are set inside rectangular receptacles within each barge module. The placement and orientation will add to overall tolerances, including module dimensional tolerances unless specific steps are taken to minimize this effect.

5.3.1.3 Stabbing Pin and Receptacle Casing Within the Assembly

The stabbing pin and the receptacle casing diameters will deviate from their theoretical dimensions. Although machined parts can be manufactured to very tight tolerances, mass production and cost considerations will limit the use of machined parts. In addition, the stabbing pin and receptacle casing position and orientation tolerances need to be added to the tolerances associated with the connector assembly and the module.

Table 5.3-1 summarizes the tolerances discussed in Sections 5.3.1.1, 5.3.1.2 and 5.3.1.3. The cumulative effect of these tolerances can result in both the stabbing pin and the receptacle casing being +/- 0.575 inches from their theoretical positions resulting in a design specified receptacle casing diameter to be 2(0.575)=1.15 inches greater than the stabbing pin. Such a loose fit between the stabbing pin and the receptacle casing is not acceptable.

Conclusions: **Dimensional tolerances for the barge module and the connector assembly need to be decoupled, preventing cumulative tolerances.**

The connector assembly should be set such that its distance from theoretical module center remains within:

- **+/- 3/8" along the longitudinal axis, and**
- **+/- 1/4" along the transverse axis.**

These tolerances represent a tradeoff between typical industry construction standards for a quality cost effective product, desirable operational flexibility and the required structural integrity.

5.3.2 Operability and Reliability

It is necessary that the stabbing pin be readily disconnected and retracted either to repair/replace the connector assembly or to disconnect the barge modules in preparation for their deactivation. At least two problems may occur during the disconnection and retraction process:

(1) Modules connected to each other will have slightly different steel weights and displacements. More importantly, the deck loads will vary from one module to another, resulting in built-in residual stresses in the stabbing pin/receptacle system. The differential loads causing such stresses and deformations will make it difficult to retract the stabbing pin.

(2) The connector assembly and the stabbing pins will be subjected to a corrosive ocean environment. Unchecked corrosion over an extended period will make it difficult to disconnect or retract the stabbing pin.

Conclusions: **Assuming that time is not a critical parameter in disengagement of the stabbing pin, either the deck loads are removed or rearranged or the module is provided with ballast. Portable pumps can be placed on deck to add ballast into a module to reduce the imbalance between modules.**

Corrosion can be minimized through the use of coatings and sacrificial anodes. Operations manuals should include appropriate inspection, maintenance and repair programs for

modules remaining on location for an extended period.

5.3.3 Structural Integrity

The connection system should be simple, provide a reliable connection and ensure structural integrity. The stabbing pin concept illustrated in the developed NFESC concept (Figure 5.3-1) consists of two segments (a nose segment and a casing segment) with a total length of about 6 feet. The nose segment consists of a steel pipe, a machined section for accepting a connector plate, and a nose section. This segment is nominally 12 inches in diameter.

The casing segment is larger in diameter (approximately 16 inches) for temporary retraction of the nose segment into the casing segment due to unwanted contact with an approaching barge module. The two segments are internally connected by an energy absorbing spring and a tension rod.

When the extended stabbing pin is inserted into a receptacle casing within the connector assembly of an adjacent module, a single guillotine plate is inserted around the machined section. A second blocking plate is inserted at the end of the larger casing stabbing pin segment.

The NFESC concept should readily resist axial compression and tension loads. However, the stabbing pin should not be subjected to shear loading (1) prior to insertion into the receptacle casing, and (2) after the lowering of the guillotine and securing of the stabbing pin.

(1) An extended stabbing pin provided with a very flexible spring will retract when subjected to very small impact loading. Thus, the shear component of a small impact loading due to directional impact will be small and the stabbing pin will not act as a fendering device. However, since the NFESC concept requires the pin to act as a fender, the stabbing pin should be capable of resisting the shear component of the upper-bound impact load without plastic deformations.

(2) Inserted guillotine and blocking plates will have relatively loose tolerances for satisfactory producibility and operability. Thus, the stabbing pin will not have adequate support to bind within the connector assembly to resist shear loads. Binding will require movement of the stabbing pin within the receptacle, and considering the extremely loose tolerances needed to effectively actuate this connection, the required movement will be significant.

Conclusions: **A compromise between a relatively flexible spring, required to minimize the loading on the extended stabbing pin due to contact with an adjacent module, and a relatively rigid spring, required to resist impact loading, will be necessary.**

The shear load transfer mechanism after connection requires further consideration. The use of single guillotine connectors at each end of the stabbing pin requires the stabbing pin to bind within the receptacle casing in order to transfer the shear load. This is a practical solution requiring the binding action to be accounted for in the design and also potentially requires significant displacement in order to engage the load and binding action. The alternative use of a double guillotines at each stabbing pin end to transfer the stabbing pin shear is also feasible, eliminates the need for significant displacement to engage the load. The use of a double guillotine is not

considered further as the load paths through the guillotines are not desirable and the concept is probably not as economically viable.

Table 5.3-1 Tolerances Compatible with Industry Standards

DEFINITION	PARAMETER	COMMENTS
I. MODULE DIMENSIONAL TOLERANCES	1. MODULE DIMENSIONS L=40'0" +/- 1/2" W=25'0" +/- 3/8" H= 8'0" +/- 1/8" 2. DIFFERENCE IN SURFACES H_{fwd} - H_{aft} < 1/8" H_{port} - H_{stbd} < 1/8" 3. DIFFERENCE IN LENGTH L_{port} - L_{stbd} < 1/2" L_{top} - L_{bot} < 3/8" 4. DIFFERENCE IN WIDTH W_{fwd} - W_{aft} < 3/8" W_{top} - W_{bot} < 1/4" 5. DEVIATION - SAG Longitudinal Bulkheads < 1/2" Transverse Bulkheads < 3/8" DEVIATION - OUT-OF-PLANE Longitudinal Bulkheads < 3/8" Transverse Bulkheads < 3/8" DEVIATION-CROSS-SECTION Combined Effect of Others	These tolerances affect both: (a) operational considerations for module-to-module contact, and (b) operability and integrity of the connection system
II. CONNECTION ASSEMBLY WITHIN THE MODULE	1. PLACEMENT WITHIN THE MODULE Longitudinal < 3/8" Transverse < 1/4" Elevation < 1/8" 2. ORIENTATION WITHIN THE MODULE Vertical Axis - y < 0.20 deg Horizontal Axis - x < 0.40 deg	Measured from theoretical center of the module Out-of-plumb based on ~1/16" Not critical
III. STABBING PIN AND CASING WITHIN THE ASSEMBLY	1. STABBING BIN & CASING DIA_{casing} - DIA_{pin} < 1/16" 2. STABBING PIN & CASING Placement < 1/8" 3. STABBING PIN & CASING Orientation < 0.40 deg	Each diameter being +/- 1/32" Each placement being +/- 1/16" Straightness being critical
IV. CUMULATIVE TOTALS	Cumulative totals along the two axes yield a resultant tolerance of ~+/- 0.575 inches for both stabbing pin and the receptacle casing. The required 1.15" clearance between the receptacle casing and the stabbing pin diameter is not acceptable. The dimensional tolerance needs to be controlled in the placement of the assembly.	Stabbing pin centerline at module outer envelope can deviate from its theoretical location due to vertical and horizontal deviations. The receptacle casing deviation can be equal to that of the stabbing pin.

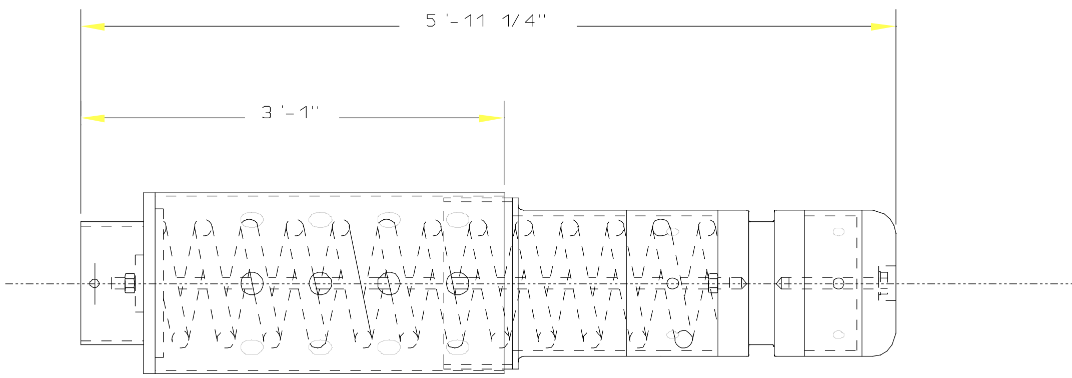


Figure 5.3-1
NFESC Concept Stabbing Pin (Ref. Dwg. 95010004)

6. DEVELOPMENT OF STRUCTURAL LAYOUT FOR SELECTED ALTERNATIVE

6.1 GENERAL

This section presents the development of the structural layout for the selected NFESC connection concept in its final form. This development was performed for the requirements specified in TM-2067-AMP (Reference 1). The initial development was performed in September and October 1995 as documented in Reference 5 and was further modified during subsequent tasks as the development progressed. The modified layout is presented in this section.

The major difference between Reference 5 and the present structural layout is in the connection concept and pin design and in the resulting dimensional requirements of the layout. Reference 5 recommended the use of double guillotine connectors in order to transfer all load components through the stabbing pin without binding of the pin within the assembly frame receptacle casing. This recommendation was later proven to be an unnecessary complication of the development concept and was rescinded, provided that the stabbing pin binding forces required to transfer the load are adequately accounted for in the design development.

6.1.1 Objectives

The primary objectives of this task were:

- to further develop the NFESC concept and produce improved structural layouts of the connector assembly and its components, and

- develop the layout of support structure to transfer loads to the barge module.

These developed layouts were used for more detailed component development in subsequent tasks (i.e., Tasks 50 and 60, References 6 and 7).

The present NFESC concepts for the stabbing pins and connector assemblies serve as starting points for further improvement of the concept. These concepts are to be assessed as to their producibility, operability, integrity and reliability characteristics and revised configurations are to be suggested, as necessary, which will offer significant improvements in these areas.

6.1.2 Scope

This task covered the following NFESC provided concept connection system components:

A) Further development of:

- connector assembly stabbing pins
- connector assembly frame

B) Development of:

- a structure layout for the added barge module hull support structure required to support the connector assembly frames and transfer imposed loads to the barge module hull structure.

6.2 CONNECTION SYSTEM STABBING PINS

6.2.1 General

This section presents the rationale and a revised configuration for the connection system stabbing pins. These revisions should lead to a stabbing pin concept with improved connection operability and load transfer capability.

The NFESC stabbing pin concept (Figure 6.2-1) serves as a basis for further refinement. It is desirable to maintain this concept wherever possible, making revisions only where needed to improve the operation or durability of the entire connection system.

6.2.2 Functional Requirements and Design Criteria

The connection system stabbing pins must perform adequately in all four of the following conditions:

- retracted - within its own connector assembly
- extended - free (not within a casing of an adjacent module connector assembly) and subject to impact prior to connection
- extended - connected (within a casing of an adjacent module connector assembly)
- extended - disconnected (within a casing of an adjacent module connector assembly) for subsequent retraction

Retracting the stabbing pin into the connector assembly requires sufficient space to stow the stabbing pin. The stabbing pin is not required to carry any significant loading under this condition. Thus, stabbing pin retractability requirements will be one design parameter for the size of the connector assembly.

When the stabbing pin is extended prior to connection, contact with approaching barge modules is certain and the stabbing pin must be able to act as a fender or readily retract due to contact. This premise is accounted for in the NFESC concept by including an energy absorbing spring within the stabbing pin assembly. This is a desirable goal. In developing the concept, it is assumed that the primary purpose of the spring is to allow the stabbing pin to temporarily retract when subjected to impact loading and still act as a fender. It is assumed that the as-designed pin capacity to resist the shear component of the impact loading without plastic deformations will be the basis for determining the spring capacity and, in turn, the fendering capacity. The major fendering is provided by the barge modules themselves should they come in contact. Impact load requirements will be another design parameter for the size of the connector assembly. Impact load requirements should not control the size of the stabbing pin, the preferred option being adjustment of the spring flexibility to reduce the impact load.

The stabbing pin strength should be controlled by loads carried during a "connected" condition. Reference 1, Section 5.2.2, recommends an initial connection system loading envelope for concept generation to be 2,500 kip-ft vertical bending moment and 110 kip vertical shear for a Sea State 5 environment. This recommendation is based on end-to-end connection of barge modules; the connection system loading envelope for side-to-side connection is assumed to be less on a per-connector basis. The design lateral bending moment and shear is also assumed to be less critical and covered by the recommended connection system loading envelope. Thus, the recommended connection system loading envelope will be used in further developing the stabbing pin configuration.

Disconnection and subsequent smooth retraction of the stabbing pin is required for quick disassembly of barge modules. This goal can probably not be totally achieved through practical design and tolerances that minimize binding of the stabbing pin and guillotine plates during connection. As discussed in Section 5 and TR-02 (Reference 4), differential loads (i.e., discrepancy of deck load and buoyancy from one module to another) and distortions may make retraction very difficult, requiring time-consuming ballasting action.

6.2.3 Stabbing Pin Configuration

The NFESC stabbing pin concept (Figure 6.2-1) has been modified only where necessary to address the concerns presented in TR-02 (Reference 2) and Section 5. The primary concern is with the stabbing pin's ability to resist shearing forces and to minimize stabbing pin binding during connection.

For a stabbing pin to resist shear forces, it must be supported at a minimum of two locations in each module. In order to minimize movement and binding within the connector assembly, the stabbing pin should be clamped at least in one location but clamping in two locations is preferred. The NFESC concept with its single guillotine and blocking plate does not provide this required restraint (unless there is no gap between the stabbing pin and receptacle casing) and therefore binding of the stabbing pin in the receptacle casing must occur in order to engage the shear load.

The resulting design forces for each stabbing pin are dependent on the applied axial and shear loads and the relative locations of the stabbing pin binding points in adjacent barge modules. Assuming the stabbing pins to be vertically spaced at 4 feet and the guillotine connections on each barge module to be spaced at a distance of 2 feet, each stabbing pin must resist a maximum axial and shear force and bending moment of approximately 313 kips, 60 kips and 540 kip-in., respectively. The stabbing pin must also resist the concentrated reaction forces at the binding locations and these reactions are severe for a tubular section. The NFESC stabbing pin concept was checked for these loads and was found adequate for all but the binding reaction force.

Modification of the stabbing pin to resist operating level shear reactions is relatively simple. At least two potential modifications are possible (Figure 6.2.-2):

- Option 1) - Revised "Shorter" Stabbing Pin Assembly:

  Increase the thickness of the 12.75" OD x 0.500" thick nose tubular. Preliminary calculations indicate that at least a 0.875 inch thickness will be required for the present design operating loads. Such a tubular section will most likely be a machined component as the tubular D/t ratio is too small to be rolled or extruded for fabrication. This would seem to be the preferred alternative as the shorter stabbing pin length results in smaller and lighter assembly frame and barge module support structures (i.e., a higher stabbing pin unit weight and cost but lower overall weight and cost).

- Option 2) - Revised "Longer" Stabbing Pin Assembly:

  Provide internal stiffening in the stabbing pin nose section at locations of high shear reaction. Such stiffeners would be relatively light but, due to the presence of the internal fendering spring, would require a longer stabbing pin with inherently longer and heavier associated structure components (e.g., connector assembly frame and barge module support structure).

6.3 CONNECTION SYSTEM ASSEMBLY FRAME

6.3.1 General

This section presents the rationale and a revised configuration for the connection system assembly. These revisions should lead to a connection system concept with improved connection operability and load transfer capability for both end-to-end and side-to-side barge module connections.

The NFESC connector assembly concept, shown on Figures 6.3-1 and 6.3-2, serves as a basis for further refinement. It is desirable to maintain this concept wherever possible, making revisions only where needed to improve the operation or durability of the entire connection system, or where needed to adapt to changes in other connection system components.

6.3.2 Functional Requirements and Design Criteria

The connector assembly must perform adequately in all four of the following conditions:

- installation and removal from the barge module
- extension and connection of the stabbing pins
- operation of interconnected barge modules
- disconnection of stabbing pins and subsequent retraction

Installation and removal from the barge module requires that the connector assembly frame be adequate to resist lifting forces. If a lifting frame is not used, the connector assembly frame should be sized accordingly, including redistribution of lifting forces due to unequal sling length or stiffness. The connector assembly frame must be easily installed and removed from the barge module; this will dictate required fabrication tolerances for the connector assembly frame and barge module support structure.

During extension of the stabbing pins and initial connection of the barge modules, the connector assembly frame must resist any imposed impact load due to barge contact. The stabbing pin energy absorbing spring should be sized to minimize this impact load.

Once the barge modules are connected, the connector assembly frame must resist loads transferred through the frame. These loads are highly concentrated in the vicinity of the stabbing pin, the guillotine plate connectors and the bearing face of the assembly.

The connector assembly frame must resist loads imposed during disconnection of the stabbing pins. Due to binding or differential loading on adjacent barge modules, these loads may well exceed those imposed during initial connection of the barge modules.

6.3.3 Connector Assembly Configuration

The NFESC connector assembly concept (Figure 6.3-1) has been modified only where necessary to accept the revised stabbing pin concept previously discussed. Additional structure has been added to the connector assembly frame to adequately transfer the stabbing pin loads into the barge module hull.

6.3.3.1 Connector Assembly Frame

The connector assembly frame structure was analyzed for adequacy under operating conditions. The rectangular tubular sizes developed for the NFESC concept are inadequate for the imposed loads used to check the stabbing pins (Section 6.2.3). High-strength (Fy=50 ksi) steel should be used throughout and many member size revisions (both upward and downward) are needed to adequately resist the imposed loads and to produce a weight efficient structure. The bearing load transfer to the vertical tubulars will need further study as these members will probably be inadequate for resisting crushing forces imposed by connecting frame members.

6.3.3.2 Stabbing Pin Actuating System

The stabbing pin actuating system is assumed acceptable. Some revision may be needed to adapt to the future changes in connector assembly frame dimensions and space constraints. Care should be taken that the actuating system does not unduly constrain the stabbing pin placement and orientation in a potential out-of-tolerance location.

6.3.3.3 Guillotine Connectors

The guillotine connector consists of relatively thick plate which is inserted through the barge module deck and simultaneously and tightly engages the connector assembly frame and connecting stabbing pin. It may be desirable to engage both connecting stabbing pins simultaneously with one guillotine connector in order to make the connection process more efficient. Such engagement has the advantage of not allowing the connection of only one stabbing pin, a situation which may overload a single stabbing pin if only one stabbing pin is present or connected.

The guillotine connector plates will be sized to adequately resist the imposed design loads (i.e., stabbing pin axial tension load) and conform to required tolerances.

6.3.4 Connector Assembly Frame Load Transfer

Barge module loads are transferred from between barge modules by direct bearing contact on the connector assembly frame or through the stabbing pins.

6.3.4.1 Connector Assembly Frame to Stabbing Pin

When load is transferred through the stabbing pins, the load must be transferred to the connector assembly frame. This transfer is made possible by the insertion of guillotine plates which provide a bearing and shear connection between the stabbing pin machined nose sections and the connector assembly frame (see Figure 6.3-1). It is at this guillotine plate connection that tolerances will be smallest since a tight connection will serve to preclude significant relative motions between barge modules and additional binding of the stabbing pins.

6.3.4.2 Connector Assembly Frame to Barge Module Structure

The connector assembly frame must transfer load to the barge module in all cases. This load transfer occurs by bearing of the connector frame assembly on support structure added to the barge module. The vertical tubular sections shown in the NFESC concept (Figure 6.3-1) will transfer the lateral load in this manner. Downward load will be transferred by bearing on the keel. Upward load will be transferred by bearing on removable assembly cap beams.

6.4 SYSTEM FUNCTIONALITY AND STRUCTURAL ARRANGEMENT

6.4.1 Stabbing Pin

The revised stabbing pin concept (Figure 6.2-2) should function as intended. The revised first alternative is very similar to the NFESC concept (Figure 6.2-1) with only an increased wall thickness in the tubular section to resist reaction forces on the stabbing pin. The second alternative requires an increase in overall length. Although small variations in stabbing pin diameter or length will not have a significant effect on the overall connection concept, changes in stabbing pin length will affect the geometry and design of the connector assembly frame and the barge module support structure, perhaps significantly.

6.4.2 Connector Assembly Frame

The revised connector assembly frame concept (Figure 6.3-2) should function as intended. The revised concept is similar to the NFESC concept (Figure 6.3-1) with high-strength steel required throughout, various revisions in frame member sizing, and added side plate structure to reduce deformation related stress in the frame structure. In general, connector assembly framing members at the outboard portion of the assembly frame should be increased in size, whereas, inboard framing members may be downsized. The weight of the revised concept is 300 pounds heavier than the NFESC concept for the first alternative and 600 pounds heavier for the second revised alternative.

6.4.3 Barge Module Hull

Recommended improvements to the stabbing pin and connector assembly frame were discussed in previous sections. The overall connection also requires additional structure in the barge module to support the connector assembly frames. This additional structure concept has not as yet been developed by NFESC. Thus, a preliminary layout for the structure immediately adjacent to the connector assembly was developed as a part of this work, was modified, and is presented on Figures 6.4-1. Other structure will be needed to connect into the barge module hull plate; this structure may be developed once barge module hull details are known.

The barge module hull will be modified to support the connector assembly and provide a watertight compartment around the connector assembly. The added compartments are necessary to maintain adequate barge module displacement and stability since the connector assemblies are open to the ocean and will be partially flooded.

The structure modifications consist of standard shipyard construction and should function as intended. The present layout consists of watertight bulkheads providing six additional watertight compartments, one at each corner of a barge module and one along each side at mid-length of each module. All watertight bulkheads surrounding the connector assemblies will require relatively light stiffening to support the bulkheads and transfer connector assembly loads to the barge module.

Detailed connection structure will also be added to transfer loads from the connector assembly frames. This structure and transfer mechanism acts in a manner similar to the guillotine system provided between the connector assembly and the stabbing pin. Figure 6.4-1 presents a schematic of this localized structure and its interface with the connector assembly frame.

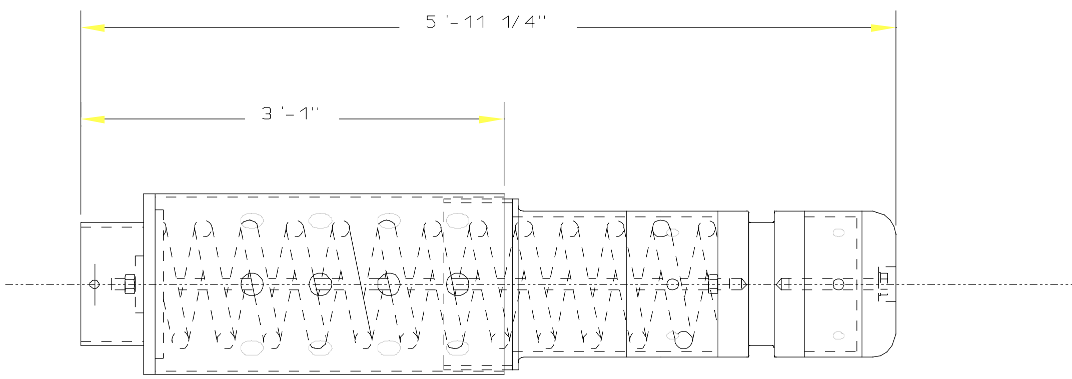
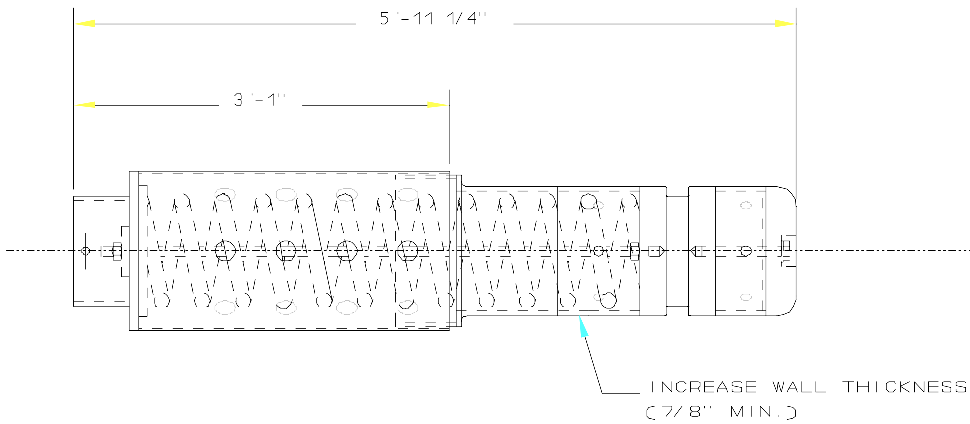
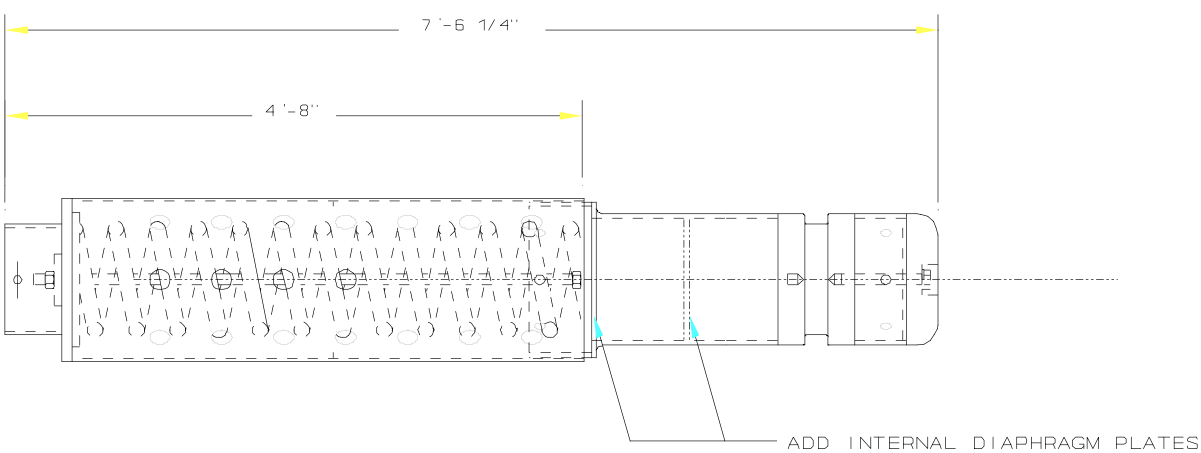


Figure 6.2-1
NFESC Concept Stabbing Pin (Ref. Dwg. 95010004)



Revised "Shorter" Stabbing Pin Assembly



Revised "Longer" Stabbing Pin Assembly

Figure 6.2-2
Revised Concept Stabbing Pin

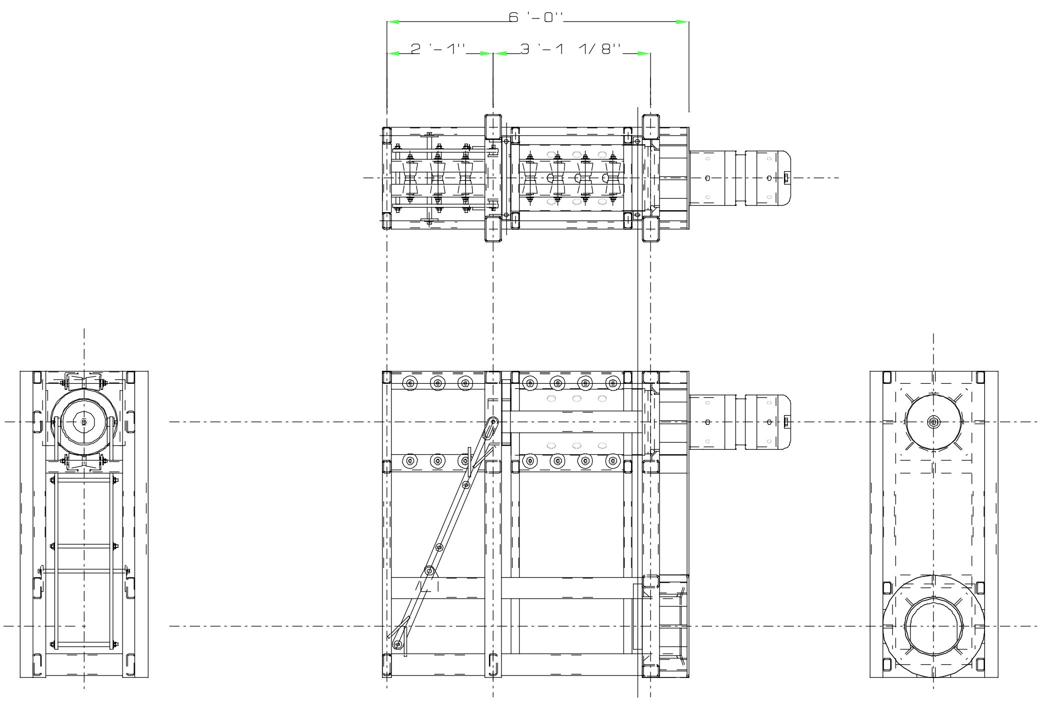


Figure 6.3-1
NFESC Concept Connector Assembly Frame (Ref. Dwg. 95010001)

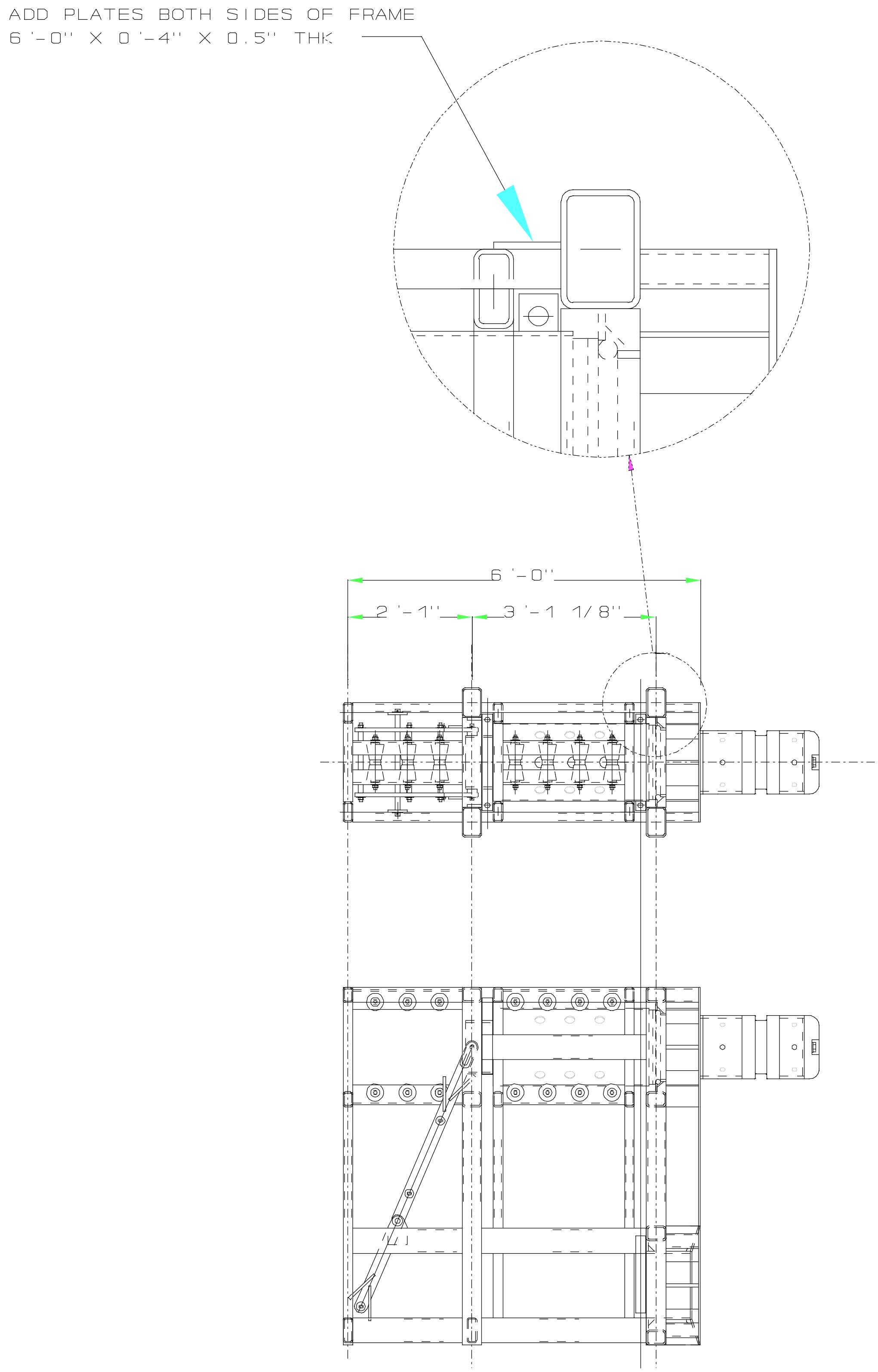
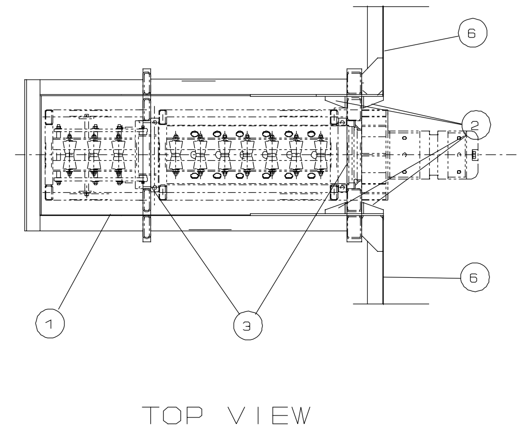


Figure 6.3-2
Revised Connector Assembly Frame



1	WT Bhd Plate w/ Stiffeners
2	Assembly Frame Guide Component
3	Cap Beams TS6x4 or TS6x2
4	Cap Beam Pin Connectors
5	Assembly Support Beams TS9x4
6	Barge Structure

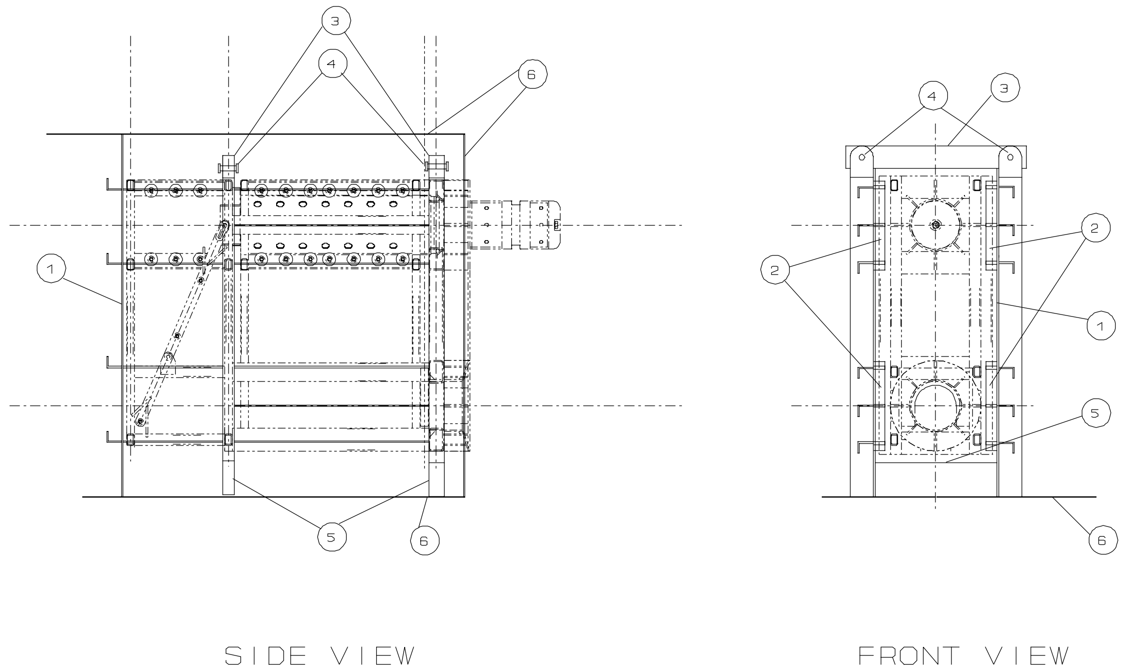


Figure 6.4-1
Additional Barge Module Structure for Connector Assembly Frame Support

7. PRELIMINARY DESIGN OF SELECTED ALTERNATIVE AND ITS COMPONENTS

7.1 GENERAL

This section presents the preliminary design of the selected NFESC connection concept and its components. This design development was performed for the requirements specified in TM-2067-AMP (Reference 1). The design initial development was performed in November 1995 as documented in Reference 6 and was further modified during subsequent tasks as the design development progressed. Modifications to the initial development are as follows:

-

7.1.2 Objectives

The primary objective of this task is to perform preliminary design of the selected connection system to meet the engineering criteria. This objective includes:

- preliminary design of the connecting cable
- preliminary design of the connection stabbing pins
- preliminary design of the connection system assembly

The present NFESC concepts for the stabbing pins and connector assemblies serve as starting points for further improvement of the concept. These concepts are to be assessed as to their producibility, operability, integrity and reliability characteristics and revised configurations are to be suggested, as necessary, which will offer significant improvements in these areas.

7.1.3 Scope

This task covered the following NFESC provided NFESC concept connection system components:

- connection system cable
- connector assembly stabbing pins
- connector assembly support frame

7.1.4 Summary

The NFESC connection concept is a viable concept that, with some slight modification, can perform its design function. Some additional future work will be required to completely optimize and/or balance the design with respect to manufacturing, performance and cost objectives.

The design recommendations resulting from this task are summarized below.

7.1.4.1 Connecting Cable

Assuming constant tension devices will not be implemented, the connection cable should be presently sized in accordance with Table 7.2-1.

7.1.4.2 Connection System Stabbing Pin

Increased tubular thickness and/or internal stiffeners are required for the stabbing pin at locations where the stabbing pin shaft bears upon the assembly frame receptacle casing. These stiffeners are required to preclude crushing of the stabbing pin tubular under bearing loads at these locations. Internal stiffeners will preclude the presence of the internal fendering spring at these locations and, in this case, the stabbing pin length must be increased approximately 19 inches to accommodate the internal spring.

7.1.4.3 Connection System Assembly Frame

The connection system assembly frame length will need to be increased if the stabbing pin length is increased. Such an increase in frame length will be approximately 19 inches.

The connector assembly stabbing pin support receptacle casing internal diameter should be at least 5/8 inch greater than the stabbing pin outer diameter to allow for tolerance considerations during manufacturing of the assembly frame and stabbing pin. The NFESC concept presently provides a diameter that is 1/4 inch greater than the stabbing pin. A 3/4 inch oversizing is preferred.

The connection system assembly frame was analyzed for lifting and operating loads. The present frame member sizing was found to be inadequate for operating loads, especially when using A36 steel. Two alternative concepts were developed assuming the use of high-strength (50 ksi) steel. The two revised concepts are consistent with a revised stabbing pin design. The first concept (Figure 7.1-1) is consistent with the "shorter" stabbing pin alternative and consists of resized frame members to resist the design loads with no major change in connector assembly frame dimensions. The second concept (Figure 7.1-2) is similar to the first but adapted to the "longer" stabbing pin concept. The first concept is slightly lighter. The first and second alternative concepts are about 300 and 600 pounds heavier, respectively, than the original NFESC concept.

7.2 CONNECTION CABLE

7.2.1 General

This section presents the rationale and preliminary design of the connecting cable used between two ocean barge modules during connection. This preliminary design should represent an upper-bound cable design for the connection system.

7.2.2 Functional Requirements and Design Criteria

The connection system cable and associated components must adequately resist loads due to the following conditions:

- tug induced tension during module connection or disconnection
- snap loading of the cable during module connection or disconnection

The maximum tug pulling force is presently 10 kips. For the design seastate (SS3), the required line number, size and potential associated snap loading is well in excess of the tug pulling force. The use of constant tension winches will reduce the magnitude of snap loading but will probably not eliminate it. Thus, it is concluded that potential snap load effects will control the design of the connection cable.

Design criteria used for the connection system cable during this phase of the project are:

- Available model basin motions data for end-to-end connection of two modules is assumed valid for side-to-side connection of tow modules as well as multiple barge module connections.

- Upper-bound snap loading without the use of constant tension winches is assumed.

7.2.3 Preliminary Design

Two independent approaches were taken to evaluate snap loading of the connection system cable. The first method is an energy method that accounts for the maximum barge kinetic energy imparted to the connecting cables based on preliminary motions analysis results (Reference 1). This method should produce an upper-bound estimate of the snap load as a function of line size and length. The second method is based on non-linear time-domain analysis of a coupled cable and barge system which, when properly used, would give a more accurate estimate of the cable snap load as a function of cable size and length.

Although time-domain analyses are outside the present scope, a representative analysis was performed to establish the relative conservatism of the energy method approach. The results of the energy method, however, are used for the present preliminary design of the connecting cable.

An upper-bound estimate of the cable snap loading was calculated assuming that the barge module motions and associated wave period are known for the design sea state. This estimate also assumes that a constant tension winch is not used; the use of such a device may further reduce the cable design requirement. Reference 1 provides an estimate of a 5 foot relative motion of two barge module ends; thus, it is assumed that each barge end has a maximum motion of 2.5 feet. Generally, this relative motion acts perpendicular to the connecting cable and has little effect on the cable loading. However, as two barge modules are pulled closer to each other, the connecting cable will begin to resist more of this relative motion and snap loads will increase. The presence of the cable will serve to damp out the barge motions but this damping is not quantifiable at present. As the barge modules approach each other, the cable will resist nearly all of the relative motion and the snap load will be a near-maximum. While the relative motion will be reduced from the 2.5 feet of Reference 1, the actual reduction can only be determined by coupled analysis. Thus, for this preliminary assessment, the design relative motion will be maintained at its maximum recommended value (Reference 1).

Following the completion of work on snap loading and issuing of the technical report (Reference 6), new information providing a comparative assessment of a proposed snap load solution method and model test results was obtained. This method was fully explored and further discussed in Section 7.2.3.3.

7.2.3.1 Energy Method

It is possible to formulate the maximum kinetic energy of two barge modules and the maximum potential energy of the connecting cable as:

$$KE = 0.5\ (m_1 v_1^2 + m_2 v_2^2)$$

$$PE = 0.5\ kx^2$$

where:

KE	= the maximum kinetic energy of two barge modules
m_1	= the mass of the first barge module
m_2	= the mass of the second barge module
v_1	= the maximum velocity of the first barge module
v_2	= the maximum velocity of the second barge module
PE	= the maximum potential energy of the connecting cable
k	= the cable stiffness = AE/L
x	= the maximum cable elongation under maximum snap loading

A	= the effective cable cross-sectional area
E	= the cable modulus of elasticity
L	= the cable length

Equating the two energy formulations and recognizing that the module maximum velocity is related to the module maximum displacement by wave period, yields the following:

$$0.5\ kx^2 = 0.5\ (\ m_1 v_1^{\ 2} + m_2 v_2^{\ 2}\ )$$

or

$$kx^2 = (\ 2\ \pi\ /\ T\ )^2\ (\ m_1 x_1^{\ 2} + m_2 x_2^{\ 2}\ )$$

The cable elongation is therefore:

$$x = (\ 2\ \pi\ /\ T\ )\ [\ (\ m_1 x_1^{\ 2} + m_2 x_2^{\ 2}\ )\ /\ k\ ]^{1/2}$$

The resulting cable snap load is:

$$T_{snap} = kx = (\ 2\ \pi\ /\ T\ )\ [\ k\ (\ m_1 x_1^{\ 2} + m_2 x_2^{\ 2}\ )\ ]^{1/2}$$

The maximum snap load is inversely proportional to the wave period, directly proportional to the barge motions, and proportional to the square root of the cable stiffness and barge mass. Of these parameters, only the cable length and size will be directly dictated by design to any appreciable extent and these parameters will be related to each other. Thus, a number of design solutions are possible.

To develop a preliminary cable design, the following assumptions were made:

- All barge module masses were assumed the same and included barge weight and added mass. The barge module weight was assumed as 75 kips, the resultant total barge module mass as 4.66 kip-s^2/ft.

- All barge module maximum motions were assumed the same at 2.5 feet.

- The associated wave period for SS3 was assumed to be 4.0 sec, a reasonable minimum.

- The number of cables per module connection is two (2).

- The cable modulus of elasticity was assumed as 14,000 ksi (for IWRC cable, Kevlar could be considered as an alternative cable material).

- The minimum factor of safety against cable failure is assumed to be 1.00. No margin is provided because this is an upper-bound estimate and the presence of the cable will in itself reduce the barge motions and associated cable snap loading, especially as the modules approach each other.

Assuming a cable length, a cable size was determined that satisfied the above assumptions. The resulting cable sizes and associated lengths are presented in Table 7.2-1. The length shown corresponds to the cable length when adjacent barge modules are in contact. When the modules are apart, the cable length increases and the cable snap loading is reduced.

7.2.3.2 Direct Time-Domain Analysis Method

Ideally, snap loading would be predicted by rigorous time-domain motions analyses of connected barge modules in the design sea state or by model testing. Time domain analyses are time-consuming and very sensitive to various modeling parameters such as mass and load distribution, mass and stiffness damping, assumed time step, etc. Nevertheless, parametric time-domain analyses of the coupled barge-cable problem should be used to further reduce the cable design requirement.

A few such analyses were performed for a single barge module connected by a cable to a fixed point using an enhanced version of NFESC's SEADYN90 (Reference 10) computer program (the enhanced version includes a wave load generator developed by I.D.E.A.S. within the "CURRENT" option of the program). The snap load varies with time and surge of the barge module and is highly dependent on modeling assumptions. As expected, the resulting snap load for a 5 foot barge module surge is less than that the upper-bound data shown on Table 7.2-1. The snap load analysis results for two 1.000 inch diameter cables 40 ft long are plotted on Figure 7.2-1.

7.2.3.3 Snap Loading of Marine Cables

Reference 11 provides another numerical integration method for predicting snap loading and motion response of cables under alternating taut-slack conditions. The method employs a lumped mass and spring model to predict the snap loads. The governing equations are integrated in the time domain by using the modified Euler method. Numerical stability analyses are also performed and the necessary stability conditions (i.e., maximum time step) given for the numerical integration.

As presented in Reference 11, this method is used to predict load and motion response for a cable fixed at one end with oscillatory motion applied at the other end. The method was programmed and validated using the model test results presented in Reference 11.

However, assuming a constant amplitude oscillatory motion at one cable end does not adequately represent the ocean barge module connection system snap load problem because the barge motions and cable snap load response are interdependent and coupled. Rigorous coupled motions analyses are required to determine the actual motions. It is expected that the presence of cables between two moving barges will serve to damp the extreme relative motions, especially as the barges approach each other. Once the actual relative oscillatory motion profile is established, the method of Reference 11 can be used to more accurately predict the actual snap loading in the connecting cable to be used for cable design.

7.2.4 <u>Conclusions and Recommendations</u>

7.2.4.1 Conclusions

The size of the cables to resist snap loading may be excessive without the use of constant tension devices. The upper-bound snap loading of 23 kip/line at a line length of 83 feet increases to 116 kip/line at a length of 37 feet. Even a small constant tension device should reduce the required line diameter significantly, especially for the shorter line lengths.

While the cost differential between the cable sizes may be offset by the cost of the constant tension devices, weight, storage space and handling characteristics of the smaller cable size are desirable.

7.2.4.2 Recommendations

The following work is recommended to further develop the connecting cable system:

- Further time-domain analyses to better estimate the extent of conservatism associated with the upper-bound snap loading approach assumed here.

- Implications of utilizing several alternative constant tension devices.

- Evaluation of new model test results (January and February 1996) and the impact on preliminary design of the connection system.

7.3 CONNECTION SYSTEM STABBING PINS

7.3.1 General

This section presents the rationale and a preliminary design configuration for the connection system stabbing pins. The enhancements of the NFESC concept included in the preliminary design should lead to a stabbing pin concept with improved connection operability and load transfer capability.

The NFESC stabbing pin concept, shown on Figure 7.3-1, serves as a basis for further refinement. It is desirable to maintain this concept wherever possible, making revisions only where needed to improve the operation or durability of the entire connection system.

Technical Report No. 40 (Reference 2) recommended a revision of the NFESC stabbing pin concept to provide a larger assembly receptacle casing diameter to ensure successful insertion of each stabbing pin into the receptacle casing built into the connector assembly framing, which in-turn is installed into the modules and meet standard fabrication tolerances. Larger diameter receptacle casings will also eliminate binding of the stabbing pin in the assembly receptacle casing under load. Three options were first considered to provide better load transfer from the stabbing pin into the connector assembly framing:

1) Provide double-guillotines and use them for direct load transfer.

2) Provide a movable wedge so that the necessary connection clearances between the receptacle casing and the stabbing pin are reduced after connection to provide improved load transfer.

3) Provide no wedges; this assumes that the barge module fabrication tolerance effects are decoupled from the connection design. The module system may "rattle" under lightship loads but once payloads are applied, any such rattling should be reduced.

The first option is considered undesirable as the guillotines are intended to secure the stabbing pin only against pull-out, not for the transfer of shear load. The second option complicates operations, possibly preventing disconnection of the stabbing pin within practical time constraints.

Since NFESC prefers a tighter fitting connection, the only viable option is to decouple the module fabrication tolerance effects from the overall design to ensure a balance between adequate stabbing pin clearance with the receptacle casing for operations, and the movement of the stabbing pin for load transfer. The preliminary design of the stabbing pin proceeded assuming the NFESC philosophy. The proposed modifications (i.e., larger diameter receptacle casing and wedges) still provide for connection and operation as intended by NFESC. Although the connection system will be subjected to binding of the stabbing pin in the receptacle casing under load, the NFESC philosophy is acceptable as long as all implications of the stabbing pin binding are accounted for in design. One such implication is having to remove deck loads to eliminate differential deformation between the barges in order to retract the stabbing pin prior to removal/repair of the assembly.

7.3.2 Functional Requirements and Design Criteria

The connection system stabbing pins must perform adequately in all four of the following conditions:

- retracted - within its own connector assembly
- extended - free (not within a casing of an adjacent module connector assembly) and subject to impact prior to connection
- extended - connected (within a casing of an adjacent module connector assembly)
- extended - disconnected (within a casing of an adjacent module connector assembly) for subsequent retraction

Retracting the stabbing pin into the connector assembly requires sufficient space to stow the stabbing pin. The stabbing pin is not required to carry any significant loading under this condition. Thus, stabbing pin retractability requirements will be one design parameter for the size of the connector assembly frame.

When the stabbing pin is extended prior to connection, contact with approaching barge modules is certain and the stabbing pin must be able to absorb impact loading before it retracts due to contact. This premise is accounted for in the NFESC concept by including an energy absorbing spring within the stabbing pin assembly. This is a desirable goal in developing the concept for two options:

1) it is assumed that the purpose of the spring is to allow the stabbing pin to temporarily retract out of the way and not act as a primary fender,

2) it is assumed that the purpose of the spring is to allow the stabbing pin to retract, absorb energy and act as a fender. It should be noted that the second option requires the stabbing pin to resist substantial bending moment as a function of the contact load lateral component.

The second option was chosen to ensure that the stabbing pin would act as a fender without suffering plastic deformation. This objective will be achieved by:

a) determining the maximum shear load capacity of the pin and the impact load magnitude to have an equivalent shear component, and

b) designing the spring to provide compatible impact load capacity before retraction.

If impact loading is high, then the major fendering is provided by the barge modules themselves should they come in contact. Impact load requirements will be another design parameter for the size of the connector assembly.

The stabbing pin strength should be controlled by loads carried during a "connected" condition. Reference 1, Section 5.2.2, recommends an initial connection system loading envelope for concept generation to be 2,500 kip-ft vertical bending moment and 110 kip vertical shear for a Sea State 5 environment. This recommendation is based on end-to-end connection of barge modules; the connection system loading envelope for side-to-side connection is assumed to be less on a per connector basis. The design lateral bending moment and shear is also assumed to be less critical and covered by the recommended connection system loading envelope. Thus, the recommended connection system loading envelope will be used in further developing the stabbing pin configuration.

Disconnection and subsequent smooth retraction of the stabbing pin is required for quick disassembly of barge modules. This goal can probably not be totally achieved through practical design and tolerances that minimize binding of the stabbing pin and guillotine plates during connection. As discussed in Section 4 and TR-02 (Reference 2), differential loads (i.e., discrepancy of deck load and buoyancy from one module to another) and distortions may make retraction very difficult, requiring time-consuming ballasting action and/or removal of deck loads.

7.3.3 Stabbing Pin Configuration

The NFESC stabbing pin concept (Figure 3.3-1) has been modified only where necessary to address the concerns presented in Section 4 and TR-02 (Reference 2). The primary concern is with the stabbing pin's ability to resist shearing forces and due to stabbing pin binding during connection. The two alternative revisions to the NFESC concept are:

Alternative 1:

- increased thickness of the stabbing pin nose tubular; the revised segment require machining for its manufacture as the required diameter to thickness ratio is too small for rolling or extrusion.

Alternative 2:

- addition of internal stabbing pin diaphragm plates to adequately resist receptacle casing reactions on the stabbing pin which would otherwise crush the stabbing pin tubular
- an increase in the stabbing pin length to accommodate the internal fendering spring

For the stabbing pin to resist shear forces, it must bind at each end of an assembly receptacle casing. The NFESC proposed lengths of each receptacle casing will result in binding reaction loads at least 15 percent larger than the shear load carried across the stabbing pin. This percentage increase is a function of the lengths of the adjacent receptacle casings and physical gap between the two receptacle casings. For the purpose of design, the receptacle casing lengths for the worst geometry have been assumed to be 6.875 and 8.875 inches with an associated gap of 2 inches. Increasing the receptacle casing length and/or reducing the gap will reduce the bearing load but such modification is not practical from the point of view of design.

Under cyclic wave load, resistance of load reversals will occur by relative movement of adjacent barge modules and subsequent binding of the stabbing pins on alternate sides of a receptacle casing. In some installations, due to the relative stabbing pin locations and orientations (i.e., tolerance considerations), it is possible that only two stabbing pins will resist the total module shear load. This possibility should be considered in the preliminary design.

For preliminary design, the worst loading case is assumed. Four stabbing pins resist the overall barge bending but only two stabbing pins resist the transverse shear and associated stabbing pin bending. Assuming the stabbing pins to be vertically spaced at 4 feet and the minimum receptacle casing length to be 6.875 inches with a gap to the adjacent receptacle casing of 2 inches, each stabbing pin assembly must resist a maximum axial and shear force and bending moment of approximately 313 kips, 62 kips, and 430 in-kips, respectively. The NFESC concept stabbing pin sizing (assumed as 12 inch Schedule 40) was checked and found to be adequate for this loading.

However, an additional concern is the ability of the stabbing pin to resist crushing forces at the edges of the receptacle casing. The present stabbing pin configuration is insufficient to resist this reaction and the required increased cylinder thickness may be impractical. There are three solutions listed in order of their overall desirability:

- Increase the nose tubular thickness to its required value. This tubular segment would be machined since its relative thickness would preclude manufacture by rolling or extrusion. Assuming this solution is achievable, it would be the most desirable from an overall connection concept point of view. The weight of the stabbing pin would increase about 80 pounds relative to the NFESC concept.

- Provide an internal diaphragm stiffener to distribute the load about the stabbing pin circumference. This would preclude the presence of the internal spring in this area of the stabbing pin and would also require a longer stabbing pin and connector assembly frame for the same sized internal fender spring. The increased stabbing pin length is on the order of 19 inches. The weight of the stabbing pin would increase about 100 pounds relative to the NFESC concept.

- Provide a solid stabbing pin rather than hollow. The required diameter is on the order of 6 inches resulting in a significantly heavier but smaller diameter stabbing pin along with a longer stabbing pin and connector assembly frame. The internal fendering spring is precluded in the nose section and the entire stabbing pin length would increase about 19 inches. This would not appear to be a preferable option and is not considered further.

7.3.4 Conclusions and Recommendations

7.3.4.1 Conclusions

Additional strengthening of the stabbing pin tubular is required at locations of bearing on the supporting receptacle casing. Such strengthening is best obtained by increasing the thickness of the over-stressed nose tubular segment or, alternatively, adding stiffener plate diaphragms inside the stabbing pin tubular. In the latter case, the stabbing pin will increase in length in order to accommodate the internal fendering spring. Shortening the spring will reduce the increase and result in a more efficient overall design, regardless of the stabbing pin modification selected.

7.3.4.2 Recommendations

The following work is recommended to further develop the stabbing pin concept:

- Further detailed tolerance studies on fabricability and connectability to optimize a balance between fabrication simplicity/cost and installation ease/problems.

- Detailed finite element analyses of the stabbing pin with respect to strength and fatigue, especially in the vicinity of cyclic bearing load on the supporting receptacle casing.

7.4 CONNECTOR ASSEMBLY FRAME

7.4.1 General

This section presents the rationale and a revised configuration for the connection system assembly. These revisions should lead to a connection system concept with improved connection operability and load transfer capability for both end-to-end and side-to-side barge module connections.

The NFESC connector assembly concept, shown on Figures 7.4-1, serves as a basis for further refinement. It is desirable to maintain this concept wherever possible, making revisions only where needed to improve the operation or durability of the entire connection system, or where needed to adapt to changes in other connection system components.

7.4.2 Functional Requirements and Design Criteria

The connector assembly must perform adequately in all four of the following conditions:

- installation and removal from the barge module
- extension and connection of the stabbing pins
- operation of interconnected barge modules
- disconnection of stabbing pins and subsequent retraction

Installation and removal from the barge module requires that the connector assembly frame be adequate to resist lifting forces. If a lifting frame is not used, the connector assembly frame should be sized accordingly, including redistribution of lifting forces due to unequal sling length or stiffness. The connector assembly frame must be easily installed and removed from the barge module; this will dictate required fabrication tolerances for the frame and barge hull supporting structure.

During extension of the stabbing pins and initial connection of the barge modules, the frame must resist any imposed impact load due to barge contact. The stabbing pin energy absorbing spring should be sized to minimize this impact load. The present capacity of the spring is 15 kips, well below the present maximum design load of 313 kips for the stabbing pin.

Once the barge modules are connected, the connector assembly must resist loads transferred through the frame. These loads are highly concentrated in the vicinity of the stabbing pin, the guillotine plate connectors, and the bearing face of the assembly.

The connector assembly must resist loads imposed during disconnection of the stabbing pins. Due to binding or differential loading on adjacent barge modules, these loads may well exceed those imposed during initial connection of the barge modules.

7.4.3 Connector Assembly Configuration

The NFESC connector assembly concept (Figure 7.4-1) has been modified only where necessary to accept the revised preliminary design stabbing pin concept previously discussed.

The preliminary design revisions to the NFESC connector assembly concept are:

- increase in receptacle casing diameter by 1/2 inch to 13-1/2 inch I.D.
- added external side plates to outboard guide slot
- increased reinforcement at locations of high load transfer
- decreased reinforcement at locations of low load transfer

- increase in assembly length to accommodate the increased stabbing pin length, if any

7.4.3.1 Connector Assembly Support Frame

The connector assembly support frame structure was analyzed for adequacy under operating conditions. Certain assumptions were necessary regarding support conditions for the assembly under operating conditions; the results presented here are not expected to be sensitive to these assumptions.

The analysis consisted of a space frame structural analysis of the connector assembly tubular structure, including the angle sections supporting the stabbing pin. The stabbing pin design axial load was determined to be 313 kips and results in a bearing load of about 8 kips/inch on the supporting tubulars. These tubulars, and some other adjacent structure, were found to be inadequate for the imposed loads, especially when using A36 steel as specified in the NFESC concept. It was also found that the adjacent smaller diameter tubulars acting as guillotine guides were over-stressed due to deformation induced stresses in the frame.

Two alternative connector assembly structures were then analyzed assuming high-strength (50 ksi) steel. Alternative No. 1 (Figure 7.4-2) consists of revised member sizes that adequately resist the design loadings and added side plates external to the outboard guillotine slot to reduce deformation-induced stresses. Alternative No. 2 (Figure 7.4-3) is similar but longer to accommodate the longer stabbing pin alternative.

Both connector assembly alternatives result in increased weight relative to the NFESC concept. The NFESC concept was estimated to weigh 2,300 lbs. Alternative 1 is estimated to weigh 2,620 pounds, an increase of 320 pounds. Alternative 2 is estimated to weight 2,880 pounds, an increase of 580 pounds. Most of the weight increase is due to under-design of the NFESC concept. Note that specifying A36 steel will result in a significantly greater weight increase for both alternatives.

7.4.3.2 Stabbing Pin Actuating System

The stabbing pin actuating system is assumed acceptable. Some revision may be needed to adapt to the future changes in connector assembly dimensions and space constraints, but such revision would have no significant impact on the overall concept.

7.4.3.3 Guillotine Connectors

The guillotine connector consists of relatively thick plate which is inserted through the barge module deck and simultaneously and tightly engages the connector assembly frame and connecting stabbing pin. It may be desirable to engage both connecting stabbing pins simultaneously with one guillotine connector in order to make the connection process more efficient. Such engagement has the advantage of precluding the connection of only one stabbing pin, a situation which may overload a single stabbing pin if only one stabbing pin is present or connected.

The guillotine connector plates transfer the 313 kip stabbing pin axial load by bearing on the stabbing pin over approximately half of the pin circumference. This results in a bearing load at the stabbing pin interface of approximately 16 kips/inch. The clear span to the supporting frame tubulars varies from a low of about 3 inches to a high of 9 inches, the shorter distance occurring at the midspan of the supporting tubulars. The shorter span guillotine will transfer a higher percentage of load, the exact distribution being quantifiable only by precise analysis. Although unconservative, taking the shorter span and average load distribution, the required guillotine plate thickness (assuming high strength steel) is about 2.25 inches; a thicker plate will actually be required. A 2.5 inch thick guillotine plate sized as per the NFESC concept will weigh about 130 pounds, excluding any attachments, making direct personnel handling difficult. Portable hand winches could be used to activate and deactivate the guillotine plates.

7.4.4 Conclusions and Recommendations

7.4.4.1 Conclusions

The following conclusions result from the design studies of this task:

- The assembly frame receptacle casing inner diameter should be at least 0.75 inches greater than the stabbing pin outer diameter.

- High-strength steel should be used for the assembly frame structure in order to adequately resist the design operating loads and minimize structure weight. Many structure tubular sizes still must be increased from the sizes shown in the present NFESC concept.

- Side plates should be added externally to the outboard guillotine slot to reduce deformation induced stresses in the connector assembly frame.

- The connector assembly frame should be lengthened as needed to accommodate an increased length in the connection stabbing pin.

7.4.4.2 Recommendations

The following work is recommended to further develop the stabbing pin concept:

- Further detailed tolerance studies on fabricability and connectability to optimize a balance between fabrication simplicity/cost and installation ease/problems.

- Detailed finite element analyses of the stabbing pin with respect to strength and fatigue, especially in the vicinity of cyclic bearing load on the supporting receptacle casing.

Cable Length (feet)	Cable Diameter (in.)	Upper-Bound Snap Load (kips/line)	Cable Breaking Load (kips/line)	Factor of Safety
37	1.125	116.5	117.0	1.00
42	1.000	92.9	93.1	1.00
48	0.875	71.1	71.2	1.00
56	0.750	52.1	52.3	1.00
67	0.625	36.2	36.3	1.00
83	0.500	23.2	23.2	1.00

Notes:

- IWRC Mooring Wire Rope assumed.
- Two (2) cables per connection assumed.

Table 7.2-1
Connecting Cable Preliminary Size Requirements

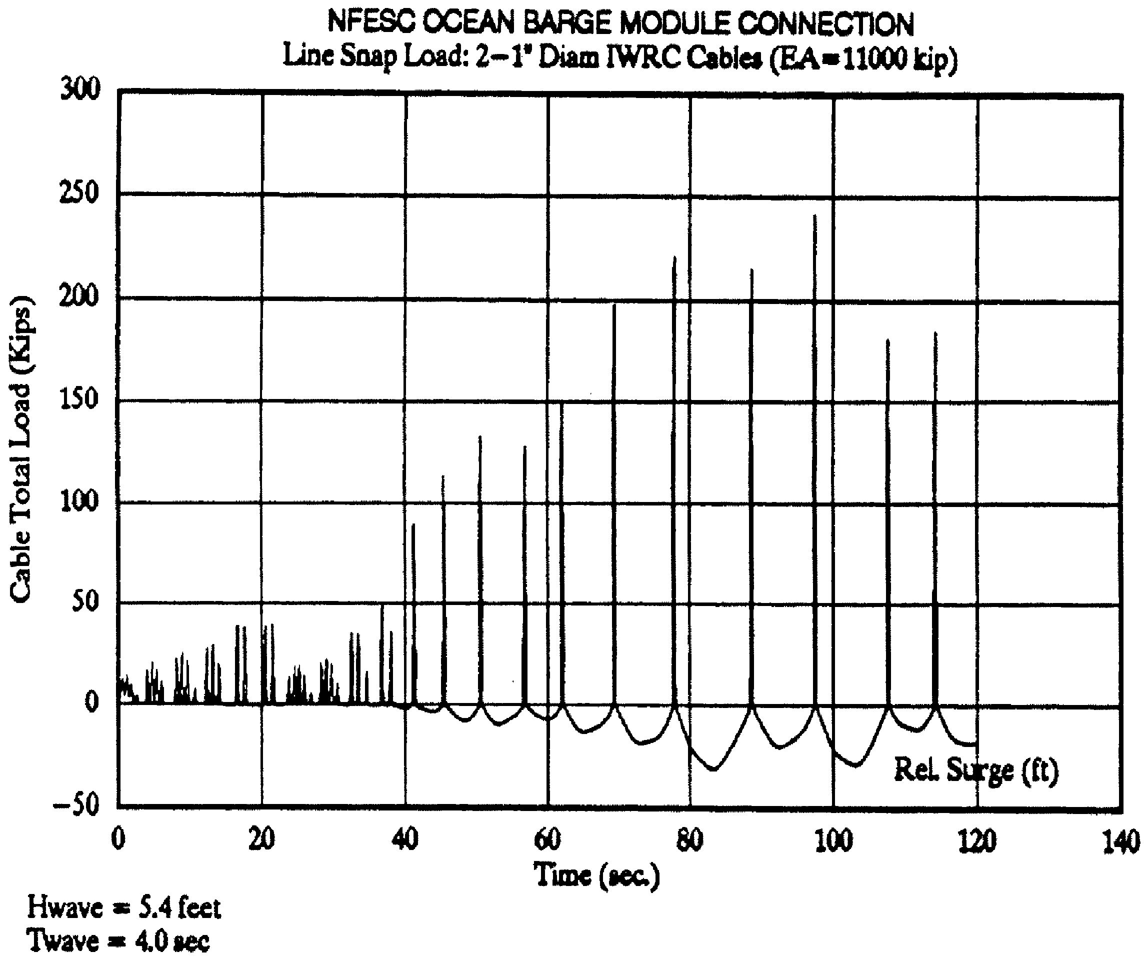


Figure 7.2-1
Preliminary Snap Load Time-Domain Analysis Results

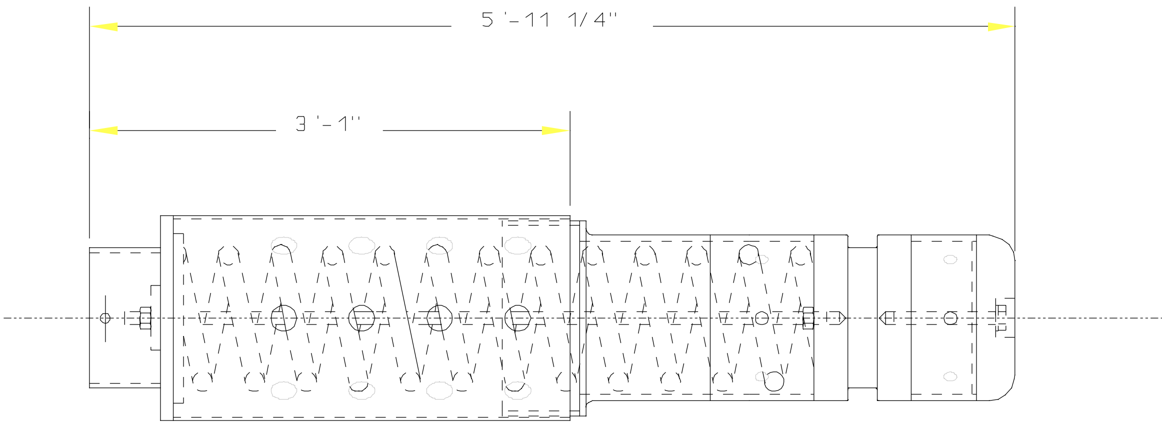
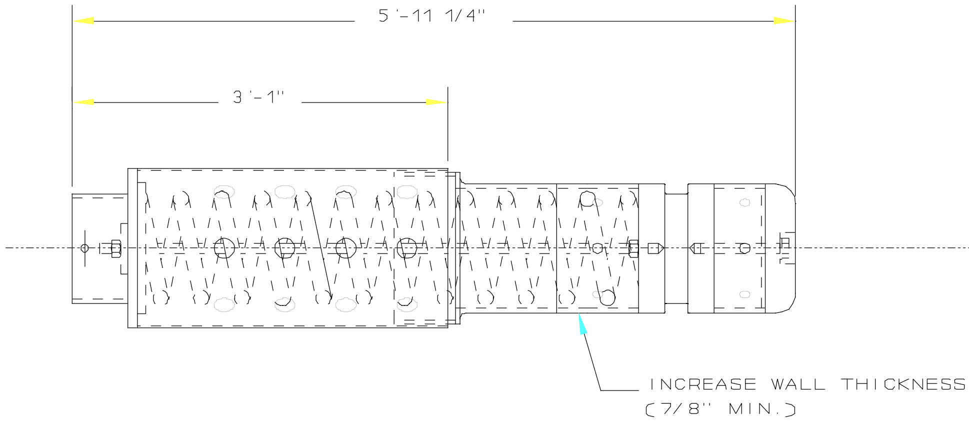
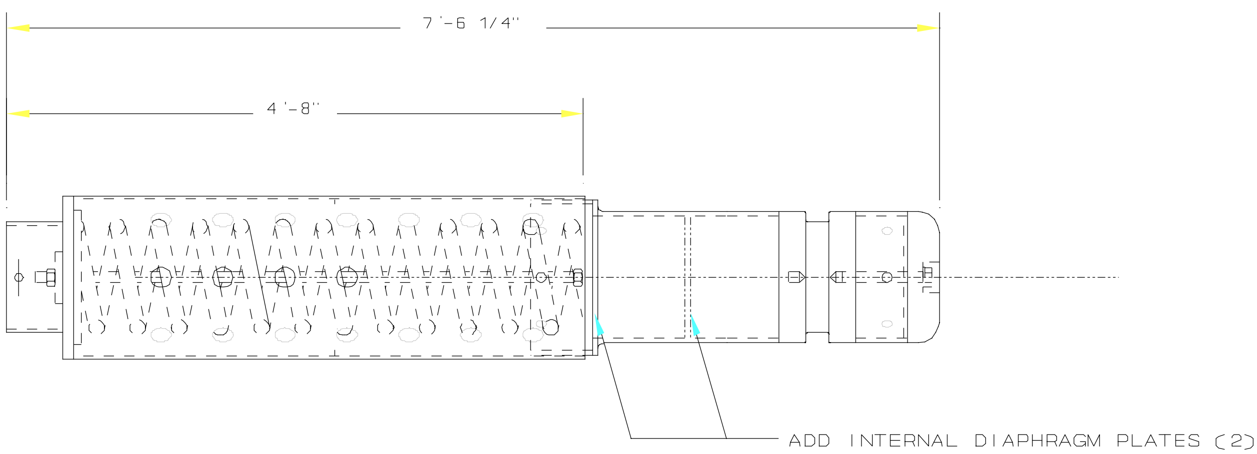


Figure 7.3-1
NFESC Concept Stabbing Pin (Ref. Dwg. 95010004)



Revised "Shorter" Stabbing Pin Assembly



Revised "Longer" Stabbing Pin Assembly

Figure 7.3-2
Preliminary Design Stabbing Pin Configurations

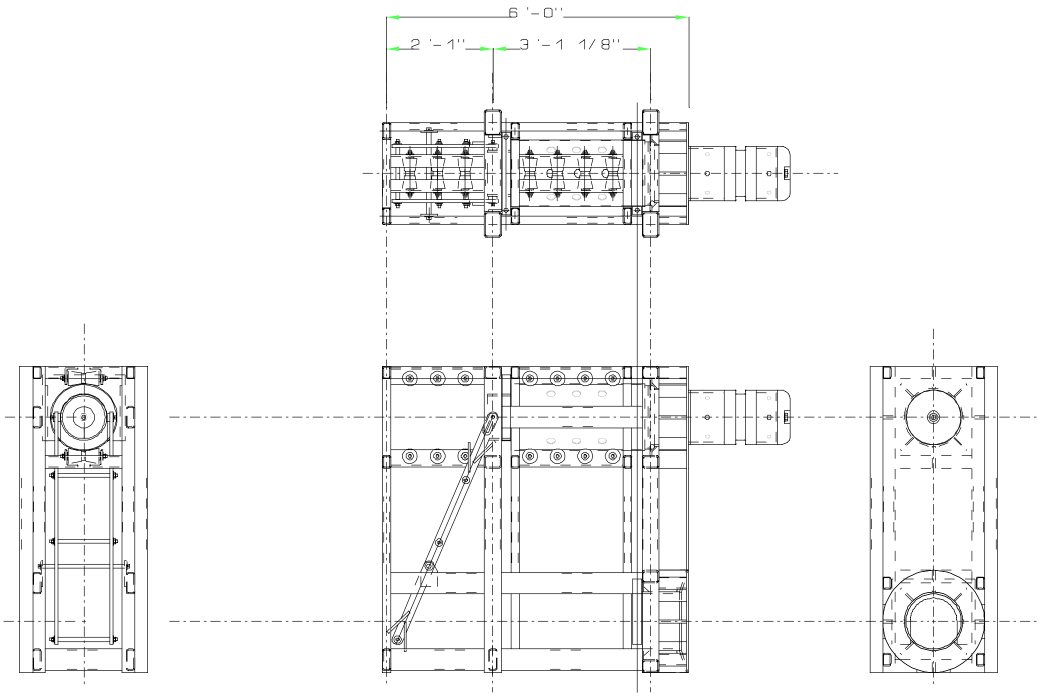
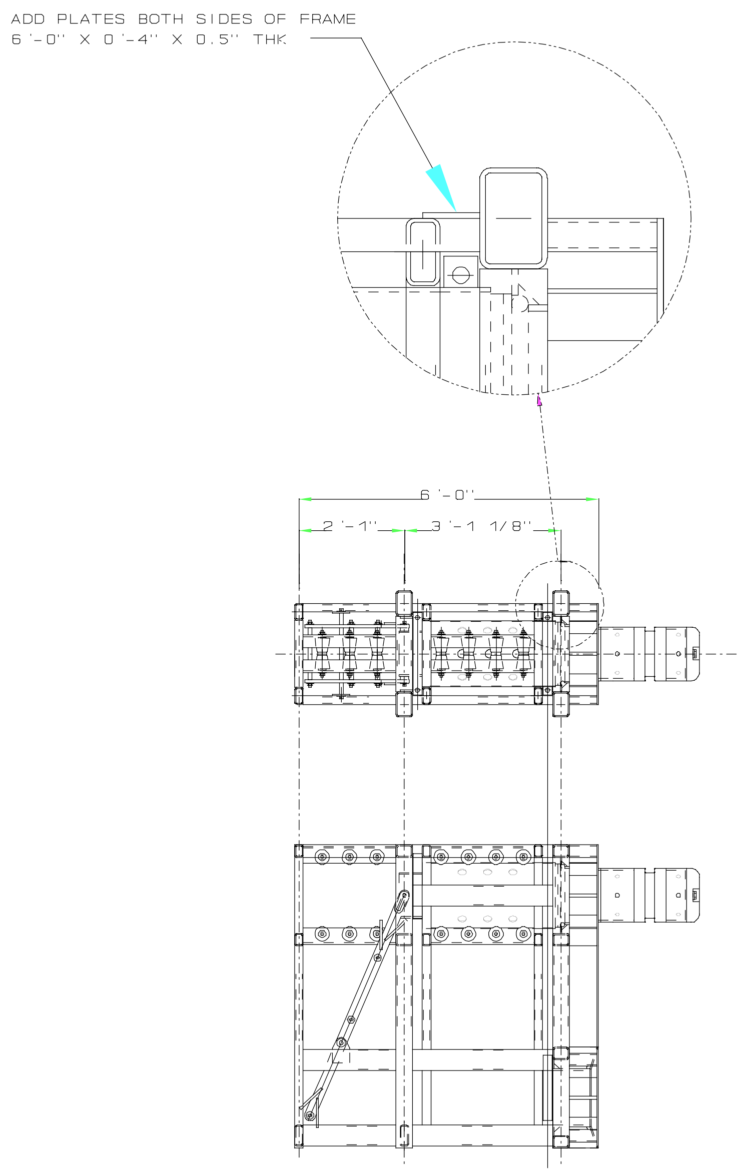


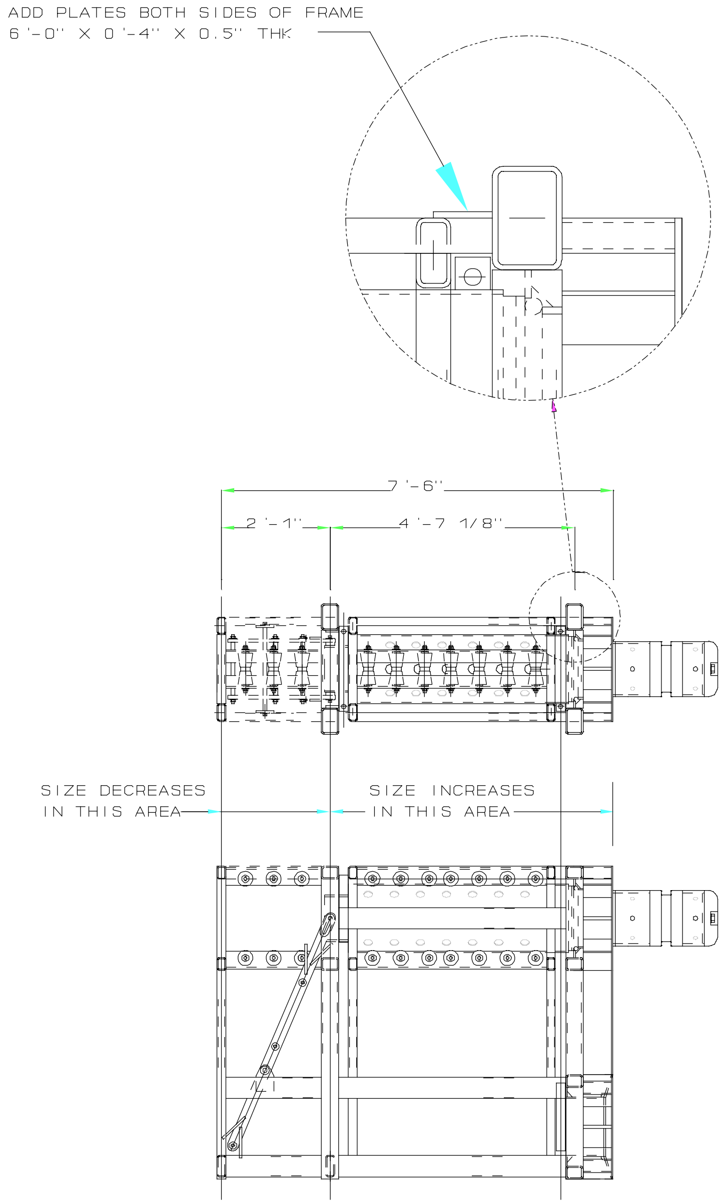
Figure 7.4-1
NFESC Concept Connector Assembly Frame (Ref. Dwg. 95010002)



Notes:

- Accommodates shorter stabbing pin configuration.
- High-strength steel (50 ksi) assumed.
- Added external side plates to outboard guillotine slot.
- Increased sizes not shown.
- Increased weight approximately 320 lbs over NFESC concept.

Figure 7.4-2
Revised Connector Assembly Frame (Alternative No. 1)



Notes:

- Accommodates longer stabbing pin configuration.
- High-strength steel (50 ksi) required.
- Added external side plates to outboard guillotine slot.
- Increased sizes not shown.
- Increased weight approximately 580 lbs over NFESC concept.

Figure 7.4-3
Revised Connector Assembly Frame (Alternative No. 2)

8. PRELIMINARY DESIGN OF BARGE MODULE SUPPORT STRUCTURE FOR THE CONNECTION SYSTEM

8.1 GENERAL

This section presents the preliminary design of the barge module support structure for the selected NFESC connection concept. This design development was performed for the requirements specified in TM-2067-AMP (Reference 1). The initial design development was performed in December 1995 as documented in Reference 7 and was further modified during subsequent tasks as the development progressed.

This section presents the rationale and a preliminary design of the barge module support structure for the connection system assembly. This preliminary support structure design should lead to an overall connection system concept with improved connection operability and load transfer capability for both end-to-end and side-to-side barge module connections.

The NFESC and revised connector assembly concepts are shown on Figure 8.1-1. The initial revised concept was developed in Task 50 and documented in Reference 5. The revised concept shown in the figure serves as a basis for the preliminary design of the support structure and any variation in the assembly concept may require a revision in the support structure preliminary design. For example, the major factor governing the revised assembly concept is the length of the stabbing pin and its internal fendering spring. The stabbing pin, assembly frame and supporting structure dimensions and weights are highly dependent on the length of the spring. Revising the spring length will have a significant effect on associated connection components; thus, minimizing the internal fendering spring length should be a high priority item for future development.

8.1.1 Objectives

The primary objective of this task is to develop an effective barge structural support system for the connection system for resisting the imposed design loads. This includes development of the following support components:

- support components to resist loads applied along the connector longitudinal axis
- support components to resist loads applied along the connector transverse axis
- support components to resist loads applied along the connector vertical axis

No NFESC barge connector assembly support structure has been provided to-date. Therefore, for the purposes of this development and weight estimation, the connector assembly support structure will be assumed independent of adjacent barge structure. It is left to future barge structure development to integrate the designs of all components so that the overall barge and support structure design is optimized with respect to weight, performance, producibility, operability, integrity and reliability characteristics.

8.1.2 Scope

This task covered the following connection system barge module support structure components:

- connection system enclosure structure
- connector assembly vertical load support structure
- connector assembly lateral load support structure

8.1.3 Conclusions

The following conclusions result from the design studies of this task:

- The support structure (and connector assembly frame) length and associated weight is dependent on the length of the connection stabbing pin. Minimizing the stabbing pin length and associated internal fendering spring should be a primary objective of final design.

- Loads applied along the connector longitudinal axis may be resisted in bearing along the entire length of the connector frame vertical columns or at discrete points along the column. The first alternative implies a support structure that fits tightly at its interface with the connector assembly frame or a relatively loose frame that permits "rattling" of the connector assembly frame within its enclosure. The second alternative implies the use of shimming devices at discrete locations to provide the desired tight fit of the connector assembly frame in the support structure.

- High-strength steel should be used for the support structure in order to adequately resist the design operating loads and minimize structure weight.

8.1.4 Recommendations

The following work is recommended to further develop the stabbing pin concept:

- Further detailed tolerance studies on fabricability and connectability to optimize a balance between fabrication simplicity/cost and installation ease/problems.

- Detailed finite element analyses of the support structure with respect to strength and fatigue, especially at locations of load transfer between the support structure and the assembly frame.

8.2 FUNCTIONAL REQUIREMENTS AND DESIGN CRITERIA

The barge structure supporting the connector assembly must perform adequately in all four of the following conditions:

- installation and removal from the barge module
- extension and connection of the stabbing pins
- operation of interconnected barge modules
- disconnection of stabbing pins and subsequent retraction

Installation and removal from the barge module requires that the connector assembly support structure be adequate to resist forces due to assembly frame lifting and installation. These loads are relatively small; thus, this is not deemed to be a controlling load condition and is not considered further.

During extension of the stabbing pins and initial connection of the barge modules, the support structure must resist any imposed impact load due to barge contact. The stabbing pin energy absorbing spring should be sized to minimize this impact load. The present capacity of the spring is 15 kips, well below the maximum design operating load of 313 kips for the stabbing pin. Thus, this condition is not deemed critical and is not considered further.

Once the barge modules are connected, the connector assembly support structure must resist loads transferred through the frame. These loads are highly concentrated in the vicinity of the stabbing pin, the guillotine plate connectors, and the bearing face of the assembly. This load condition will control the design of the support structure and the support structure design should reflect the high concentration of loads at discrete locations.

The connector assembly must resist loads imposed during disconnection of the stabbing pins. Due to binding or differential loading on adjacent barge modules, these loads may well exceed those imposed during initial connection of the barge modules. However, these loads are not quantified at present and such quantification is outside the scope of this task. Such loads are assumed not to control the support structure design and are not considered further.

Thus, the design loads used in developing the preliminary design of the support structure are those recommended for SS5 conditions in Reference 1. The controlling design loads are as follows:

- Barge hogging and sagging moment: 2,500 ft-kips
- Vertical shear (lateral is less): 110 kips

8.3 PRELIMINARY DESIGN

8.3.1 General Layout

The support structure layout reflects the performance requirements of this structure. The general layout is shown with and without the installed connector assembly frame on Figures 8.3-1 and 8.3-2.

Since the connector assembly must be open to the sea, the connector assembly should be enclosed by a watertight structure to prevent flooding of the entire barge module. At present, the connector enclosure is at least 6.0 feet long, 2.5 feet wide and 8.0 feet high. The watertight structure will consist mainly of lightly stiffened relatively thin steel plate; some additional local increased thickness may be needed to transfer the connector loads to the barge structure through this plate. However, assuming 1/4 inch thick plate, the plate enclosure alone (i.e., not including stiffening) will weigh over 1,100 pounds per enclosure.

The top of the compartment is open to the deck for installation and removal of the assembly. This opening may be covered by deck plate or grating. Grating is lighter, more easily handled and implies a desirable light load zone in the area of the connectors.

The actual load transfer from the connector assembly occurs in the outboard vicinity of the enclosure since this is the location where the connector loads are transferred from the stabbing pins to the assembly frame. It is less efficient to transfer loads to the inboard segments of the frame and then into the support structure since the outboard hull structure will eventually carry the load. This rationale is reflected in the support structure layout.

The vertical loads are supported by cross beams above and below the frame. The beams under the frame are a permanent part or the barge and support structure and should be incorporated into the overall barge module design. The beams above are removable to allow installation and removal of the assembly frame. The upper beams are pin connected to the barge and support structure just below deck to provide a smooth deck surface. The upper beams could be provided with a storage slot below decks or be completely removed when not in use as specified by operating procedures.

8.3.2 Longitudinal Loads

The support structure will resist longitudinal loads from the assembly frame due to surge motion of the barge structures and overall bending of the barge structure due mainly to hogging or sagging. Horizontal bending of the barge modules will also occur but, at present, this effect is considered small relative to the vertical bending moment.

The 2,500 ft-kip design vertical bending moment, applied on two connector assemblies, produces a 313 kip couple along the stabbing pin axes (presently separated by 48 inches). This couple is resisted by the barge module support structure at discrete points along the length of the two 6-foot long TS6x4 connector assembly columns. The resisting loads are triangularly distributed with a maximum transferred load of approximately 96 kips near each column end. This load is used to size the adjacent horizontal stiffener plates, bulkhead plate and stiffener angles along the height of the support structure.

The enclosure plate is initially sized at 1/4 inch thick in order to transfer this load in shear to the adjacent barge deck and keel structure. Locally thicker plate may be required and a more detailed finite element analysis of this area is needed to better define the local stress distribution in this area.

8.3.3 Transverse Loads

Loads applied transverse to the connector axis have not been developed but are assumed significantly less than other design loads. Transverse loads should affect only the design of two support structure columns. This should be checked in final development once design transverse loads are quantified.

8.3.4 Vertical Loads

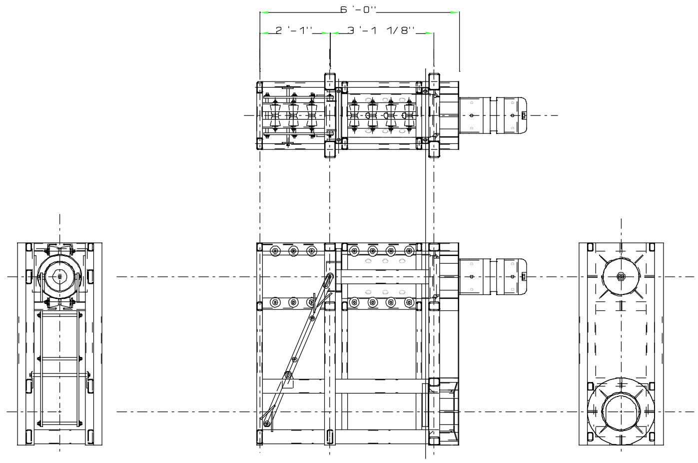
The 110 kip barge module design vertical load is assumed applied on two connectors since stabbing pin binding and barge module differential loading are not likely to place 100 percent of the design load on one connector. The support structure resists this load through direct bearing on top and bottom cross beams. The bottom beams are an integral part of the barge module structure. The top beams are removable and stabbing pin-connected at their ends. The beams are designed for the shear and bending moment due to a 55 kip vertical design load on one connector.

8.4 TOLERANCE CONSIDERATIONS

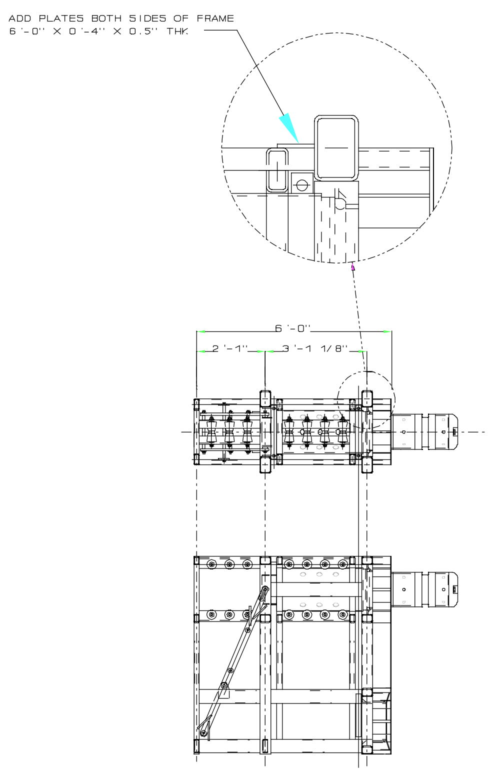
Sufficient fabrication tolerances will be required to ensure that at-sea connections will be capable of being made. Of primary importance is placing each connector assembly in its "exact" theoretical position in a barge module and with respect to other connector assemblies. The actual position is not as important as the relative position as long as there is sufficient gap between barge modules to account for any actual overall position out-of-tolerance.

The key to the fabrication is then to decouple the relative position tolerance from tolerances associated with the frame assembly fabrication. This can be done by providing adjustments in the support structure fabrication after that structure has been installed in the barge module through the use of shim plates or other such devices. A template assembly frame would be installed in each connector enclosure and all template face plates surveyed for actual location. The proper shim devices would then be installed to force an installed assembly frame to the proper location.

Shim plates would be required at four locations above and below an assembly frame and at four to eight locations on each side of an assembly frame. The shim plates would be installed in the shipyard during fabrication of the module. Surveying all six face plate theoretical locations in the shipyard to a relatively tight (e.g., +/- 1/16 inch) but practical tolerance should be a part of the fabrication specifications for the barge module.

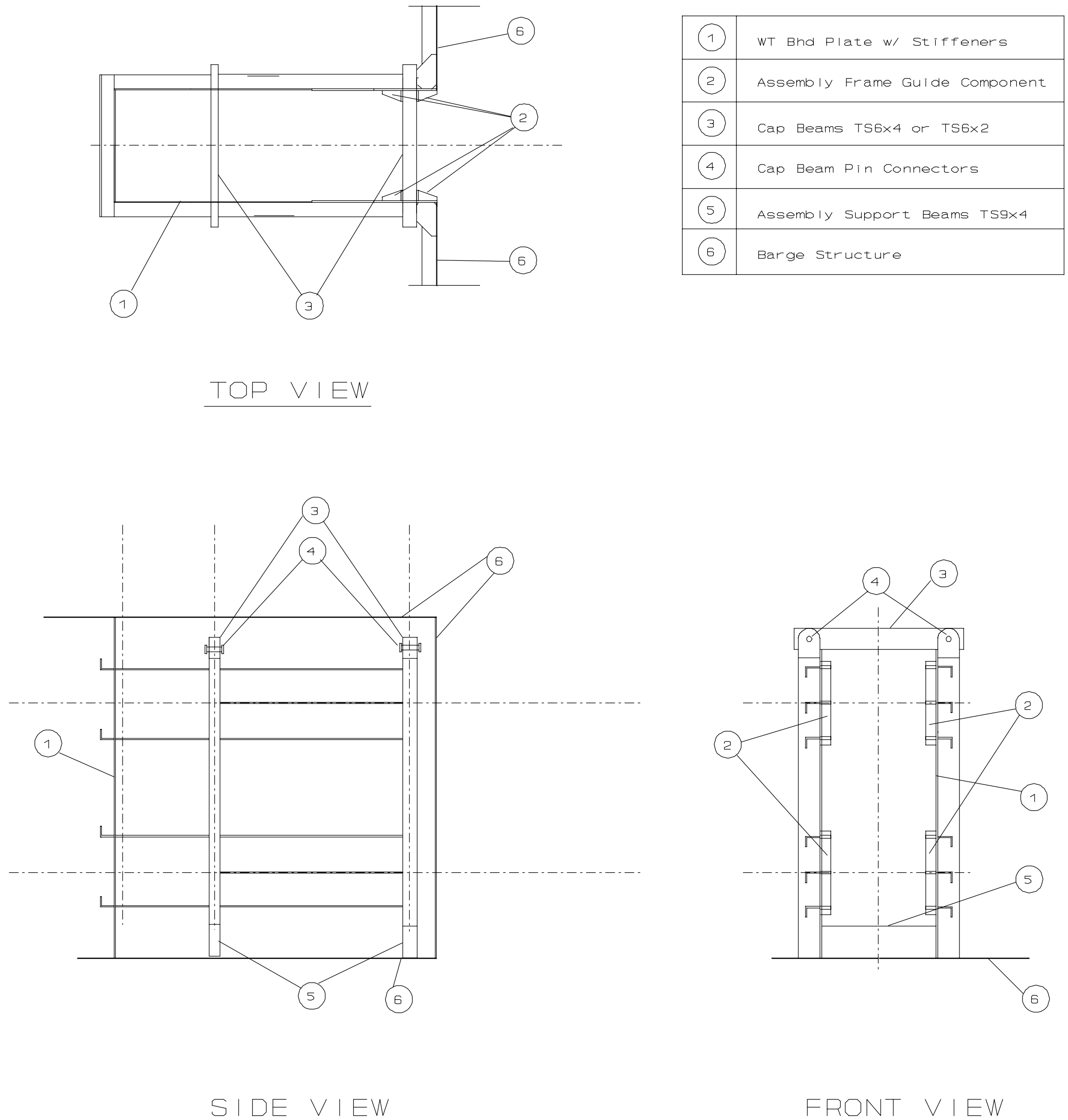


NFESC concept (Ref Dwg 95010001)



Revised Concept

Figure 8.1-1
NFESC and Revised Connector Assembly Frame Concepts



1	WT Bhd Plate w/ Stiffeners
2	Assembly Frame Guide Component
3	Cap Beams TS6x4 or TS6x2
4	Cap Beam Pin Connectors
5	Assembly Support Beams TS9x4
6	Barge Structure

Figure 8.3-1
Barge Connector Assembly Support Structure

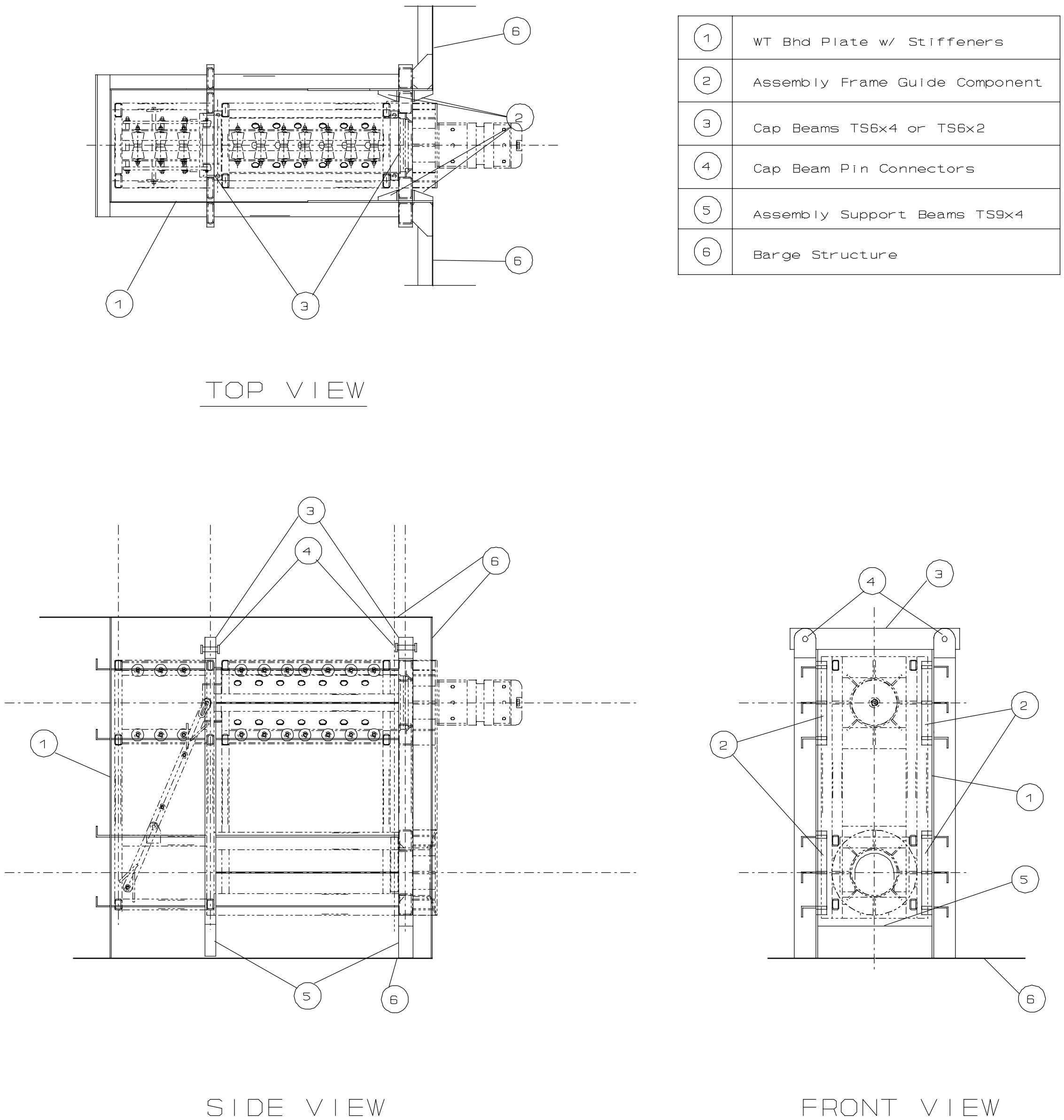


Figure 8.3-2
Barge Connector Assembly Support Structure with Assembly Installed

9. DEVELOPMENT OF MATERIALS LIST, ESTIMATED WEIGHTS AND COSTS

9.1 GENERAL

This section presents the development of materials lists, estimated weights and estimated costs for the selected NFESC connection concept. This data development was performed for the requirements specified in TM-2067-AMP (Reference 1). The initial data development was performed in December 1995 as documented in Reference 8 and was further modified during subsequent tasks as the development progressed. Modifications to the initial data development are as follows:

- Connector assembly frame receptacle casings were resized to 14.25" OD x 13.50" ID
- Added plates external to the connector assembly frame outboard guillotine slots were downsized

9.1.2 Objectives

The primary objective of this task is to develop material lists, estimated weights and estimated costs for connection system components and associated barge module support structure.

9.1.3 Scope

This task covered the material lists development and weight and cost estimation for the following:

- connection cable
- connector stabbing pin
- connector assembly frame
- barge module support structure for connector assembly

NFESC has provided drawings (Reference 2) of their stabbing pin and connector assembly frame concept. These drawings serve as a basis for developing the materials list for these components modified to reflect recommended revisions from the previous preliminary design development tasks (Tasks 50 and 60, References 6 and 7).

9.1.4 Connector Concept Revisions Incorporated Into Materials List

This section briefly summarizes the resulting revisions proposed in previous tasks. In some cases, the conclusions of the TRs have been modified to reflect the latest development philosophy.

9.1.4.1 Connecting Cable

Preliminary design of the connecting cables is documented in Section 6 and Reference 6. The cable diameter is a function of the length of the cables and the magnitude of expected snap loading. Table 6.2-1 tabulates various cable size requirements as a function of cable length at the time of maximum snap loading. For the present purposes, it is assumed that at least 40 feet of cable is contained within the barge and on decks when the barge modules are connected. Therefore, two 1-inch diameter IWRC mooring wire rope cables are required.

9.1.4.2 Connector Stabbing Pin

The connector stabbing pin should be revised to provide adequate strength in the nose section to resist shearing loads due to binding of the stabbing pin in the assembly frame receptacle casing. Two alternatives are presently proposed:

Alternative 1: Increase the thickness of the critical nose section from its present 1/2 inch thickness to approximately 7/8 inch in order to adequately resist the imposed crushing forces on the tubular section. This alternative would require a machined tubular segment (replacing items 10 and 11 on Drawing 95010004, Ref. 1) 12.75 inches in outer diameter, 7/8 inch thick, and 18 inches long with a lapped joint stub end. The internal fendering spring and the stabbing pin length would remain as is. This alternative minimizes the assembly frame and barge module support structure lengths and results in increased displacement capacity of the barge module. This is alternative is designated as the "shorter stabbing pin" alternative.

Alternative 2: Provide diaphragm plates in the nose section to reinforce the nose tubular against crushing under load. This alternative precludes the presence of the internal fendering spring and, assuming no change in the spring length, requires an increase in the stabbing pin length of approximately 19 inches. The increased stabbing pin length results in an increased length of assembly frame and barge module support structure, and reduced displacement capacity of the barge module. This alternative is designated as the "longer stabbing pin" alternative.

9.1.4.3 Connector Assembly Frame

The connector assembly frame was analyzed for design operating loads and documented in Reference 1. The tubular sizes should be increased to resist the imposed loads regardless of the selected stabbing pin alternative. The selected stabbing pin alternative will influence the overall length, weight and cost of the assembly frame but will have a minimal effect on the framing sizes. Thus, two alternatives for the assembly frame are considered as a function of the selected stabbing pin alternative. These alternatives are:

- Alternative 1: Revised assembly frame with shorter stabbing pin (Stabbing Pin Alternative 1).

- Alternative 2: Revised assembly frame with lengthened stabbing pin (Stabbing Pin Alternative 2).

9.1.4.4 Barge Module Support Structure for Connector Assembly

A preliminary design of the barge module support structure for the connector assembly was performed for the design operating loads and documented in Section 9. The preliminary design sizes to resist the imposed loads will be the same regardless of the selected stabbing pin alternative. The selected stabbing pin alternative will influence only the overall length, weight and cost of the support structure. Thus, two alternatives for the assembly frame are considered as a function of the selected stabbing pin alternative. These alternatives are:

- Alternative 1: Support structure to accommodate a shorter stabbing pin (Stabbing Pin Alternative 1).

- Alternative 2: Support structure to accommodate a lengthened stabbing pin (Stabbing Pin Alternative 2).

9.2 MATERIALS LIST AND ESTIMATED WEIGHTS

A draft materials lists is presented in Appendix C. Estimated weights are tabulated at the end of this section for each connector component. Summary estimated weights for all connector components are presented in Table 9.2-1.

9.2.1 Connection Cable

Two 1-inch diameter IWRC mooring wire rope cables are assumed. The maximum length of cable is a function of the maximum separation distance of two modules prior to cable connection and pull-in. The draft materials list and the estimated weight presented in Table 2.1-1 assume a required cable length of 200 feet for each cable.

9.2.2 Connector Stabbing Pin

Draft materials lists for the two alternative stabbing pin concepts are presented in Appendix C; respective weight estimates are presented in Tables 9.2-3 and 9.2-4.

Reference to those items appearing in the NFESC drawings (Reference 2) is also provided, where applicable. The differences in the two alternatives are due to the configuration of the stabbing pin nose section and the associated length of the larger stabbing pin receptacle casing.

9.2.3 Connector Assembly Frame

Draft materials lists for the two alternative connector assembly frame concepts are presented in Appendix C; respective weight estimates are presented in Tables 9.2-5 and 9.2-6.

Reference to those items appearing in the NFESC drawings (Reference 2) is also provided, where applicable. The only difference in the two alternatives is the length of the central section of the assembly frame to accommodate the associated stabbing pin alternative.

9.2.4 Barge Module Support Structure for Connector Assembly

Materials lists for the two alternative barge module support structure connector assembly frame concepts are presented in Appendix C; respective weight estimates are presented in Tables 9.2-7 and 9.2-8.

The only difference in the two alternatives is the length of the bulkhead enclosure to accommodate the associated stabbing pin alternative.

9.3 ESTIMATED COSTS

Estimated costs are tabulated on Table 9.3-1 for each connector component. The estimate should be accurate to within plus or minus 20 percent. Connection cable and related costs are omitted from this estimate since this is dependent on cable lengths, sizes and other design parameters that are presently unknown.

9.3.1 Connector Stabbing Pin

Estimated costs for the two alternative stabbing pin concepts are presented on Table 9.3-1. The differences in the two alternatives are due to the configuration of the stabbing pin nose section and the associated length of the larger stabbing pin receptacle casing.

9.3.2 Connector Assembly Frame

Estimated costs for the two alternative connector assembly frame concepts are presented on Table 9.3-1. The only difference in the two alternatives is the length of the central section of the assembly frame to accommodate the associated stabbing pin alternative.

9.3.3 Barge Module Support Structure For Connector Assembly

Estimated costs for the two alternative barge module support structure connector assembly frame concepts are presented on Table 9.3-1. The only difference in the two alternatives is the length of the central section of the assembly frame to accommodate the associated stabbing pin alternative.

The connector components are relatively light but will require extensive surveying, placement and/or shimming adjustments to minimize subsequent out-of-tolerance installation of the assembly frame. A lump-sum cost per module assembly is therefore assigned to this item.

Connector Assembly Alternative No. 1
(Shorter Stabbing Pin Alternative)

Component	Item	Item Wgt (lbs)	Qty	Total Wgt (lbs)
Connector Cable	1" Diam IWRC Wire Rope	370	2	740
Stabbing Pin	See Table 9.2-3	953	6	5,718
Assembly Frame	See Table 9.2-5	2,619	6	15,714
Support Structure	See Table 9.2-7	3,263	6	19,578
TOTAL (one module)		----	---	41,750

Note: Six (6) connectors assumed per barge module.

Connector Assembly Alternative No. 2
(Lengthened Stabbing Pin Alternative)

Component	Item	Item Wgt (lbs)	Qty	Total Wgt (lbs)
Connector Cable	1" Diam IWRC Wire Rope	370	2	740
Stabbing Pin	See Table 9.2-4	975	6	5,850
Assembly Frame	See Table 9.2-6	2,878	6	17,268
Support Structure	See Table 9.2-8	3,667	6	22,002
TOTAL (one module)		-----	---	45,120

Note: Six (6) connectors assumed per barge module.

Table 9.2-1
Connector Assembly Estimated Weights for One Barge Module

Component	Item	Item Wgt (lbs)	Qty	Total Wgt (lbs)
Connector Cable	1" Diam IWRC Wire Rope	370	2	740
				740

Note: Two (2) 200-ft long cables assumed per barge module.

Table 9.2-2
Connector Cable Estimated Weights for One Barge Module

Connector Stabbing Pin Alternative No. 1
(Shorter Stabbing Pin Alternative)

Component	Item: Description	Item: Ref	Item Wgt (lbs)	Qty	Total Wgt (lbs)
Stabbing Pin Case	Tube 15.75" OD x 15.25" ID x 30.5" LG	3	105	1	105
	Bar 13" ϕ x 0'-3/4"	4	28	1	28
	Bar 15 3/4" ϕ x 0'-1"	5	55	1	55
	Tube 10.75" OD x 10" ID x 5.5" LG	6	19	1	19
	Bar 0.75" ϕ x 0'-3"	7	1	1	1
	SUBTOTAL - stabbing pin Case				208
Stabbing Pin Nose	15" OD x 14.25" ID x 0'-6" LG	9	29	1	29
	Lap Joint Stub End, 12" Pipe Size x 7/8" THK x 24" LG, Machined, ASTM A234, Seamless Welding Fitting	10/11	114	1	114
	Tube 12.75" OD x 11.75" ID x 0'-5" LG Hot Finished Seamless, ASTM A53 Gr. B	12	27	1	27
	Bar 12.75" ϕ x 0'-7.5" LG, machined	13	248	1	248
	Bar 11.75" ϕ x 0.375" THK	14	11	1	11
	SUBTOTAL - Stabbing Pin Nose				506
Stabbing Pin Misc	Cap, 12.75" ϕ x 0'-3" LG, Machined, PVC	15	30	1	30
	Cap Screw, 1-8UNC x 0'-8", Hex Hd, Zinc Plated, SAE Gr.2	16		1	
	Washer, 2" OD x 1-1/16" ID x 9/64" THK, Zinc Plated	17		1	
	Bar 1" ϕ x 4'-6" LG	19	16	1	16
	Nut, 1-8UNC, Hex, Zinc Chromate, SAE Gr.2	20	1	1	1
	Spring	21	188	1	188
	stabbing pin Plate	22	4	1	4
	SUBTOTAL - Stabbing Pin Miscellaneous				238
TOTAL (one stabbing pin)			---	---	953
TOTAL (one module)			953	6	5,718

Note: Six (6) connectors assumed per barge module.
All material is high-strength (Fy=50 ksi) steel unless otherwise noted.
Item References refer to NFESC Drawing 95010004.

Table 9.2-3
Estimated Weights for Connector Stabbing Pin (Alternative No. 1)

Connector Stabbing Pin Alternative No. 2
(Longer Stabbing Pin Alternative)

Component	Item		Item Wgt (lbs)	Qty	Total Wgt (lbs)
	Description	Ref			
Stabbing Pin Case	Tube 15.75" OD x 15.25" ID x 30.5" LG	3	171	1	171
	Bar 13" ϕ x 0'-3/4"	4	28	1	28
	Bar 15 3/4" ϕ x 0'-1"	5	55	1	55
	Tube 10.75" OD x 10" ID x 5.5" LG	6	19	1	19
	Bar 0.75" ϕ x 0'-3"	7	1	1	1
	SUBTOTAL - stabbing pin Case				274
Stabbing Pin Nose	15" OD x 14.25" ID x 0'-6" LG	9	29	1	29
	Lap Joint Stub End, 12" Pipe Size XS, 16" LG, ASTM A234, Seamless Welding Fitting	10	65	1	65
	Tube 12.75" OD x 11.75" ID x 0'-8" LG Hot Finished Seamless, ASTM A53 Gr. B	11	44	1	44
	Tube 12.75" OD x 11.75" ID x 0'-5" LG Hot Finished Seamless, ASTM A53 Gr. B	12	27	1	27
	Bar 12.75" ϕ x 0'-7.5" LG, machined	13	248	1	248
	Bar 11.75" ϕ x 0.375" THK	14	11	1	11
	Stiffs, 11.75" ϕ x 0.500" THK		19	2	38
	SUBTOTAL - Stabbing Pin Nose				463
Stabbing Pin Misc	Cap, 12.75" ϕ x 0'-3" LG, Machined, PVC	15	30	1	30
	Cap Screw, 1-8UNC x 0'-8", Hex Hd, Zinc Plated, SAE Gr.2	16		1	
	Washer, 2" OD x 1-1/16" ID x 9/64" THK, Zinc Plated	17		1	
	Bar 1" ϕ x 4'-6" LG	19	16	1	16
	Nut, 1-8UNC, Hex, Zinc Chromate, SAE Gr.2	20	1	1	1
	Spring	21	188	1	188
	stabbing pin Plate	22	4	1	4
	SUBTOTAL - Stabbing Pin Miscellaneous				238
TOTAL (one stabbing pin)			---	---	975
TOTAL (one module)			975	6	5,850

Note: Six (6) connectors assumed per barge module.
All material is high-strength (Fy=50 ksi) steel unless otherwise noted.
Item References refer to NFESC Drawing 95010004.

Table 9.2-4
Estimated Weights for Connector Stabbing Pin (Alternative No. 2)

Connector Assembly Frame Alternative No. 1
(Shorter Stabbing Pin Alternative)

Component	Item Description	Ref	Item Wgt (lbs)	Qty	Total Wgt (lbs)
Assembly Frame Structure	TS3X2X.250		316	1	316
	TS4X2X.250		198	1	198
	TS4X3X.3125		23	1	23
	TS5X2X.3125		144	1	144
	TS6X2X.375		390	1	390
	TS6X4X.500		491	1	491
	L4X3X3/8		144	1	144
	Tube 14.25" OD x 13.50" ID x 16.5"		76	1	76
	Bar, 4" x 3/8" x 0'-6"		10	1	10
	Stiff	18	24	1	24
	Stiff	19	24	1	24
	Stiff	20	20	1	20
	Stiff	21	20	1	20
	End Plate	22	181	1	181
	Plate	23	16	1	16
	Plate	24	18	1	18
	Funnel Plate	25	89	1	89
	Ring	28	10	1	10
	Plate (added) 6'-0" x 4" x 0.5"		42	2	84
	Guillotine Plates 2.25" THK		132	2	264
	SUBTOTAL - Assembly Frame Structure				2,542
Assembly Frame Roller	Washer, 1.75" OD x 11/16" ID x 9/64" THK	8	0.1	28	3
	Nut, 5/8-11UNC, Hex, Zinc Chromate, SAE Gr. 2	9	0.2	28	6
	Keel Roller, 8" Nom., Rubber, Stl Sleeves, Nylon Bushings	12	1	14	14
	Bar, 5/8" ϕ x 11" LG	13	0.96	14	13
	SUBTOTAL - Assembly Frame Roller				36
Assembly Frame Lever	Bar 2.50" x 0.75" x 59.375" LG	3	31.6	1	31.6
	Bar 2.00" x 0.75" x 5.50" LG	4	2.3	1	2.3
	Bar 0.500" ϕ x 7.00" LG	5	1.6	1	1.6
	Bar 1" ϕ x 16.000" LG	7	3.5	1	3.5
	Washer, 1.75" OD x 11/16" ID x 9/64" THK	8	0.1	2	0.2
	Nut, 5/8-11UNC, Hex, Zinc Chromate, SAE Gr. 2	9	0.2	2	0.4
	Lever Shaft, Bar 1" ϕ x 21.500" LG	10	4.8	1	4.8
	SUBTOTAL - Assembly Frame Lever				44
TOTAL (one assembly)			---	---	2,619
TOTAL (one module)			2,619	6	15,714

Note: Six (6) connectors assumed per barge module.
All material is high-strength (Fy=50 ksi) steel unless otherwise noted.
Item References refer to NFESC Drawings 95010002 or 9501005, as applicable.

Table 9.2-5
Estimated Weights for Connector Assembly Frame (Alternative No. 1)

Connector Assembly Frame Alternative No. 2
(Longer Stabbing Pin Alternative)

Component	Item Description	Ref	Item Wgt (lbs)	Qty	Total Wgt (lbs)
Assembly Frame Structure	TS3X2X.250		316	1	316
	TS4X2X.250		198	1	198
	TS4X3X.3125		23	1	23
	TS5X2X.3125		224	1	224
	TS6X2X.375		500	1	500
	TS6X4X.500		491	1	491
	L4X3X3/8		197	1	197
	Tube 14.25" OD x 13.50" ID x 16.5"		76	1	76
	Bar, 4" x 3/8" x 0'-6"		10	1	10
	Stiff	18	24	1	24
	Stiff	19	24	1	24
	Stiff	20	20	1	20
	Stiff	21	20	1	20
	End Plate	22	181	1	181
	Plate	23	16	1	16
	Plate	24	18	1	18
	Funnel Plate	25	89	1	89
	Ring	28	10	1	10
	Plate (Added) 6'-0" x 4" x 1/2"		42	2	84
	Guillotine Plates 2.25" THK		132	2	264
	SUBTOTAL - Assembly Frame Structure				2,785
Assembly Frame Roller	Washer, 1.75" OD x 11/16" ID x 9/64" THK	8	0.1	40	4
	Nut, 5/8-11UNC, Hex, Zinc Chromate, SAE Gr. 2	9	0.2	40	8
	Keel Roller, 8" Nom., Rubber, Stl Sleeves, Nylon Bushings	12	1	20	20
	Bar, 5/8" ϕ x 11" LG	13	0.96	20	19
	SUBTOTAL - Assembly Frame Roller				51
Assembly Frame Lever	Bar 2.50" x 0.75" x 59.375" LG	3	31.6	1	31.6
	Bar 2.00" x 0.75" x 5.50" LG	4	2.3	1	2.3
	Bar 0.500" ϕ x 7.00" LG	5	1.6	1	1.6
	Bar 1" ϕ x 16.000" LG	7	3.5	1	3.5
	Washer, 1.75" OD x 11/16" ID x 9/64" THK	8	0.1	2	0.2
	Nut, 5/8-11UNC, Hex, Zinc Chromate, SAE Gr. 2	9	0.2	2	0.4
	Lever Shaft, Bar 1" ϕ x 21.500" LG	10	4.8	1	4.8
	SUBTOTAL - Assembly Frame Lever				44
TOTAL (one assembly)			---	---	2,878
TOTAL (one module)			2,878	6	17,268

Note: Six (6) connectors assumed per barge module.
All material is high-strength (Fy=50 ksi) steel unless otherwise noted.
Item References refer to NFESC Drawings 95010002 or 9501005, as applicable.

Table 9.2-6
Estimated Weights for Connector Assembly Frame (Alternative No. 2)

Barge Module Support Structure for Connector Assembly Alternative No. 1
(Shorter Stabbing Pin Alternative)

Component	Item		Item Wgt (lbs)	Qty	Total Wgt (lbs)
	Description	Re f			
Bulkhead Enclosure	Bulkhead Plate, 1/4" x 8'-0" x 14'-6"		1,183	1	1,183
	Angle Stiff, L4x3x3/8 x 14'-6"		128	6	768
	Crnr Stiff, 1/2" Plate		5.1	12	61
	SUBTOTAL - Enclosure Bulkheads				2,012
Bulkhead Framing	TS6X4X.500		701	1	701
	TS6X2X.375		340	1	340
	Padeyes		7.5	8	60
	Stabbing Pins		4.5	4	18
	Nuts		0.5	4	2
	SUBTOTAL - Enclosure Framing				1,121
Assembly Support	Stiff Plate		2.1	24	50
	Bearing Plate		6.2	8	50
	Shim Plate (lot)		2.5	12	30
	SUBTOTAL - Assembly Frame Lever				130
TOTAL (one assembly)			---	---	3,263
TOTAL (one module)			3,263	6	19,578

Note: Six (6) connectors assumed per barge module.
All material is high-strength (Fy=50 ksi) steel unless otherwise noted.

Table 9.2-7
Estimated Weights for Connector Barge Module Support Structure (Alternative No. 1)

Barge Module Support Structure for Connector Assembly Alternative No. 2
(Longer Stabbing Pin Alternative)

Component	Item Description	Item Ref	Item Wgt (lbs)	Qty	Total Wgt (lbs)
Bulkhead Enclosure	Bulkhead Plate, 1/4" x 8'-0" x 17'-6"		1,428	1	1,428
	Angle Stiff, L4x3x3/8 x 17'-6"		154.3	6	926
	Crnr Stiff, 1/2" Plate		5.1	12	61
	SUBTOTAL - Enclosure Bulkheads				2,416
Bulkhead Framing	TS6X4X.500		701	1	701
	TS6X2X.375		340	1	340
	Padeyes		7.5	8	60
	Stabbing Pins		4.5	4	18
	Nuts		0.5	4	2
	SUBTOTAL - Enclosure Framing				1,121
Assembly Support	Stiff Plate		2.1	24	50
	Bearing Plate		6.2	8	50
	Shim Plate (lot)		2.5	12	30
	SUBTOTAL - Assembly Frame Lever				130
TOTAL (one assembly)			---	---	3,667
TOTAL (one module)			3,667	6	22,002

Note: Six (6) connectors assumed per barge module.
All material is high-strength (Fy=50 ksi) steel unless otherwise noted.

Table 9.2-8
Estimated Weights for Connector Barge Module Support Structure (Alternative No. 2)

Estimated Connection Cost (Alternative No. 1)
(Shorter Stabbing Pin Alternative)

Component	Sub-Component	Weight (lbs)	Unit Cost ($/lb)	Cost ($)
Stabbing Pin	Stabbing Pin Case	208	2.00	420
	Stabbing Pin Nose	506	5.00	2,530
	Stabbing Pin Miscellaneous	238	3.00	710
	SUBTOTAL - Stabbing Pin	**953**		**3,660**
Assembly Frame	Assembly Frame Structure	2,542	2.50	6,360
	Assembly Frame Roller	36	5.00	180
	Assembly Frame Lever	44	5.00	200
	SUBTOTAL - Assembly Frame	**2,619**		**6,740**
Barge Module Support Structure	Bulkhead Structure	2,012	2.00	4,020
	Support Framing	1,121	2.00	2,240
	Connector Components	130	n/a	3,000
	SUBTOTAL - Support Structure	**3,263**		**9,260**
TOTAL (one connector assembly)		6,835		19,660
TOTAL (one barge module)		41,010		118,000

Estimated Connection Cost (Alternative No. 2)
(Longer Stabbing Pin Alternative)

Component	Sub-Component	Weight (lbs)	Unit Cost ($/lb)	Cost ($)
Stabbing Pin	Stabbing Pin Case	274	2.00	550
	Stabbing Pin Nose	463	5.00	2,320
	Stabbing Pin Miscellaneous	238	3.00	710
	SUBTOTAL - Stabbing Pin	**975**		**3,600**
Assembly Frame	Assembly Frame Structure	2,785	2.50	6,960
	Assembly Frame Roller	51	5.00	240
	Assembly Frame Lever	44	5.00	200
	SUBTOTAL - Assembly Frame	**2,878**		**7,400**
Barge Module Support Structure	Bulkhead Structure	2,416	2.00	4,830
	Support Framing	1,121	2.00	2,240
	Connector Components	130	n/a	3,000
	SUBTOTAL - Support Structure	**3,667**		**10,070**
TOTAL (one connector assembly)		7,520		21,100
TOTAL (one barge module)		45,120		126,600

Note: Estimated costs include material, handling and fabrication and assembly costs. Costs associated with offshore installation of connector assemblies and connection of barge modules are not included.

Table 3-1
Estimated Costs for Connector Components

10. SUMMARY OF POTENTIAL MODIFICATIONS TO SYSTEM COMPONENTS

10.1 GENERAL

This section summarizes the potential modifications to system components for the selected NFESC connection concept. This modification development was performed for the requirements specified in TM-2067-AMP (Reference 1). The initial modification development was performed in December 1995 as documented in Reference 9.

10.1.1 Objectives

The primary objective of this work is to develop potential modifications to connection system components that will improve the concept with respect to producibility, operability, integrity and reliability considerations and allow operation for both end-to-end and side-to-side connection scenarios. The structural performance implications of the connection configuration should also be considered when enhancing the concept.

10.1.2 Scope

This work covered the development of potential modifications for the following system components:

- connection cable
- connector stabbing pin
- connector assembly frame
- barge module support structure for connector assembly

NFESC has provided drawings (Reference 1) of their stabbing pin and connector assembly frame concept. These drawings have served as a basis for previous tasks and subsequent development of modifications to the NFESC concept (Tasks 50 and 60, References 6 and 7).

10.2 CONNECTION CABLE

The design cable length and size are interdependent parameters. Previous work has established a relationship between these two parameters as a function of barge module mass and relative barge motion during connection operations in SS3 environments. The resulting cable sizes and associated lengths are presented in Table 10.2-1. The length shown corresponds to the cable length when adjacent barge modules are in contact. When the modules are apart, the cable length increases and the cable upper-bound snap loading is reduced.

Presently it is assumed that the minimum effective cable length during barge connection is 42 feet. Thus, two 1 inch diameter IWRC cables are assumed for the present connection system development. Under this scenario, a constant tension device is not assumed. The data shown on Table 10.2-1 are upper-bound values and should result in less onerous requirements based on more comprehensive analyses during detailed design. The detailed design may result in further development and in the use of constant tension device(s) and/or longer cable lengths. The connecting cable size should then be modified to reflect the design basis and assumed design parameters.

10.3 CONNECTOR STABBING PIN

10.3.1 General

The connector stabbing pin must adequately resist loads due to:

- barge operations in SS5 environments
- connection and disconnection in SS3 environments

Stabbing pin design operating loads were developed from Reference 1 based on an operating maximum vertical bending moment of 2,500 ft-kips and a vertical shear of 110 kips. The stabbing pin is adequate for these design loads with the exception of the shear reaction on the nose section tubular. This 12.75" OD x 0.500" thick tubular section must be modified in order to adequately resist the imposed design loads.

During connection or disconnection, the stabbing pin is subject to impact from the adjacent barge. An internal fendering spring is provided to allow the spring to deform along the stabbing pin axis thereby minimizing impact loads along the stabbing pin axis. Impact perpendicular to the stabbing pin axis is more critical as such impact must be resisted by the strength of the stabbing pin.

10.3.2 Potential Stabbing Pin Modifications

Modification of the stabbing pin to resist operating level shear reactions is relatively simple. At least two potential modifications are possible (Figure 10.3-1):

- Option 1) - Revised "Shorter" Stabbing Pin Assembly:

  Increase the thickness of the 12.75" OD x 0.500" thick nose tubular. Preliminary calculations indicate that at least a 0.875 inch thickness will be required for the present design operating loads. Such a tubular section will most likely be a machined component as the tubular D/t ratio is too small to be rolled or extruded for fabrication. This would seem to be the preferred alternative as the shorter stabbing pin length results in smaller and lighter assembly frame and barge module support structures (i.e., a higher stabbing pin unit weight and cost but lower overall weight and cost).

- Option 2) - Revised "Longer" Stabbing Pin Assembly:

  Provide internal stiffening in the stabbing pin nose section at locations of high shear reaction. Such stiffeners would be relatively light but, due to the presence of the internal fendering spring, would require a longer stabbing pin with inherently longer and heavier associated structure components (e.g., connector assembly frame and barge module support structure).

A third option of providing double guillotines, revising the stabbing pin to suit, and transferring all operating loads through the stabbing pin instead of the receptacle casings was previously considered but rejected as too complex and contrary to NFESC requirements.

10.4 CONNECTOR ASSEMBLY FRAME

10.4.1 General

The connector assembly frame consists of a welded steel tubular space frame with stabbing pin receptacle casings, connector guillotine plates and associated slots, bearing face plates and other ancillary components. The majority of the assembly frame acts as a holding area for retracted stabbing pins and is therefore lightly loaded. The structure in the vicinity of the bearing face plates and stabbing pin receptacle casings is highly stressed during connection and operating load conditions. The assembly frame structure in this area is of relatively heavier sizing.

The assembly frame was modeled for structural analysis and analyzed for lifting and design operating conditions. The analysis and subsequent development of the assembly frame depends on the load application from the stabbing pins, guillotine plates and the bearing plate assembly and on the support provided by the barge module support structure. The load application itself is rather straightforward since either the stabbing pin loads the guillotine plates over approximately half the stabbing pin perimeter or adjacent assemblies bear on each other at their face plate assemblies providing compression more or less concentrically about the center of the stabbing pin. In either case, shear load is transferred through the stabbing pin which must rack to a certain extent within the receptacle casing.

The barge module support of the assembly can be provided at a variety of locations but it will be most efficient to provide support in the vicinity of the applied stabbing pin loads, namely, at the first vertical assembly tubular column nearest the receptacle casings. Additionally, it will be more advantageous to provide discrete support points along the tubular column so that the reaction is concentrated into relatively significant resisting structure rather than distributed along relatively thin bulkhead plates. This will also allow shimming of the support components during barge fabrication in order to minimize any subsequent out-of-tolerance installation of the assembly frame.

Given these assumptions on applied load distribution and resulting support reactions the assembly frame, as originally sized, was found to be inadequate at locations in the vicinity of the stabbing pin receptacle casings and guillotine plates. This was generally due to the specification of mild-strength steel (A36) but also due to undersizing of the framing components even when high-strength (Fy 50 ksi) steel was assumed. There is also significant vierendeel deformation in the rectangular panels adjacent to the receptacles which causes high local bending stresses in many of the steel tubular sections that is difficult to eliminate through size increases alone.

Tubular sections well removed from the points of concentrated load application are generally oversized and some weight reduction can be realized by downsizing these members. High strength steel is still recommended in this area, however.

10.4.2 Potential Connector Assembly Frame Modifications

Proposed modifications of the connector assembly frame fall into four categories:

- modification of the assembly frame consistent with modifications to the stabbing pin configuration
- modification of the assembly frame configuration to affect load distribution within the assembly frame
- upgrading of member sizes at high stress locations
- downgrading of member sizes at low stress locations

10.4.2.1 Modifications Consistent with Stabbing Pin Configurations

It is proposed that the stabbing pin nose section be modified in one of two ways as discussed in Section 10.3. In one case, this would involve increasing the stabbing pin length approximately 19 inches. A similar length increase would be required in the assembly frame central bay (see Figure 10.4-1) to accommodate a lengthened stabbing pin in both its connected and stowed positions.

Fabrication tolerances specified for the assembly frame fabrication should be as tight as practical but overly tight tolerances will be relatively costly and may be impractical to achieve. Practical tolerances suggested for this fabrication were evaluated relative to the ability to successfully install four stabbing pins. This evaluation results in a minimum design "gap" of 1/2 inch between the stabbing pin outer diameter and the receptacle casing inner diameter; the present gap is 1/4 inch. Thus, the inner diameter of the receptacle casing should be modified accordingly.

10.4.2.2 Modifications Affecting Design Load Distribution

High deformation-induced stresses occur in the rectangular frames, especially in the short lengths of tubular sections adjacent to the guillotine slots. Simply increasing the tubular sizes will not suffice as this will not significantly reduce the imposed deformations unless the rectangular frame is triangulated. The most efficient solution is to change the load resisting elements in this immediate area by plating the slot and welding this plate to the adjacent tubulars. This is easily done on the outside of the adjacent tubulars (Figure 10.4-2). Modeling and stiffness analysis of the connector assembly frame indicate that the deformation-induced stresses are significantly reduced with this modification.

10.4.2.3 Upgrading of Members at High-Stress Locations

Most members in the vicinity of the guillotine slots are undersized especially if mild-strength (A36) steel is used. Therefore, high-strength (50 ksi) steel is recommended throughout, even for low-stress locations. In addition, many tubular sections require increased wall thickness and, in some cases, an increase in tubular size (Figure 4.2-2).

10.4.2.4 Downgrading of Members at Low-Stress Locations

Most members well removed from the stabbing pin receptacle casings are understressed and may be downsized (Figure 4.2-2). Such members consist of the vertical columns at the rear of the assembly frame and structure used primarily to support the stabbing pin when it is stowed. High-strength steel should still be used in these locations since the low quantity of steel involved in each assembly frame and the potential for fabrication errors make mixed steel strength usage impractical for this application. Furthermore, barge module support of this low-stressed steel should be minimized or preferably eliminated so as not to attract operation-induced loads to these locations. This is relatively easy to accomplish in design.

10.5 BARGE STRUCTURE SUPPORT

The design of the overall barge structure should include the structure support for the connector assembly frames. At present, NFESC has not provided an initial concept for the barge module support structure so the concept presented in Section 6 and this section is considered the initial design concept requiring further work. It is left to the overall barge designer to incorporate this initial concept into the overall barge design so that an efficient barge structure arrangement results.

The barge module support structure layout reflects the performance requirements of this structure. The general layout is shown with the installed connector assembly frame on Figure 10.5-1.

Since the connector assembly must be open to the sea, the connector assembly should be enclosed by a watertight structure to prevent flooding of the entire barge module. The watertight structure will consist mainly of lightly stiffened relatively thin steel plate; some additional local increased thickness may be needed to transfer the connector loads to the barge structure through this plate. However, assuming 1/4 inch thick plate, the plate enclosure alone (i.e., not including stiffening) will weigh over 1,100 pounds per enclosure.

The top of the compartment is open to the deck for installation and removal of the assembly. This opening may be covered by deck plate or grating. Grating is lighter, more easily handled and implies a desirable light load zone in the area of the connectors.

The actual load transfer from the connector assembly occurs in the outboard vicinity of the enclosure since this is the location where the connector loads are transferred from the stabbing pins to the assembly frame. It is less efficient to transfer loads to the inboard segments of the frame and then into the support structure since the outboard hull structure will eventually carry the load. This rationale is reflected in the support structure layout.

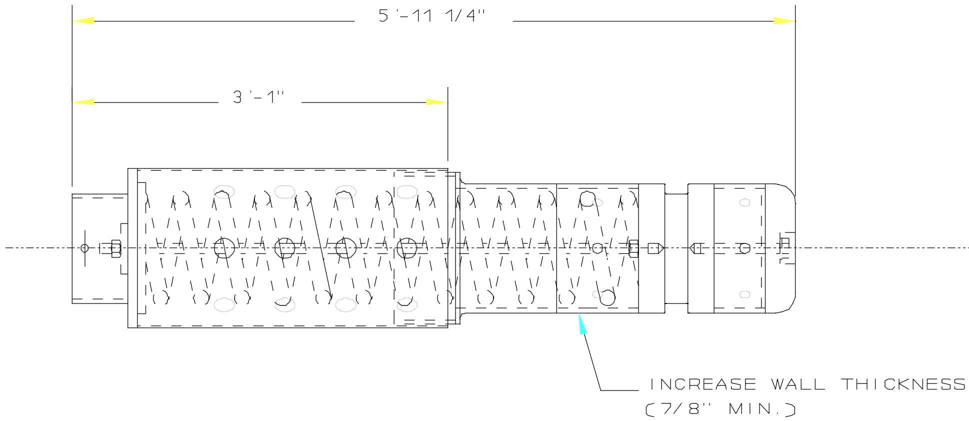
The vertical loads are supported by cross beams above and below the frame. The beams under the frame are a permanent part of the barge and support structure and should be incorporated into the overall barge module design. The beams above are removable to allow installation and removal of the assembly frame. The upper beams are pin connected to the barge and support structure just below deck to provide a smooth deck surface. The upper beams could be provided with a storage slot below decks or be completely removed when not in use as specified by operating procedures.

Cable Length (feet)	Cable Diameter (in.)	Upper-Bound Snap Load (kips/line)	Cable Breaking Load (kips/line)	Factor of Safety
37	1.125	116.5	117.0	1.00
42	1.000	92.9	93.1	1.00
48	0.875	71.1	71.2	1.00
56	0.750	52.1	52.3	1.00
67	0.625	36.2	36.3	1.00
83	0.500	23.2	23.2	1.00

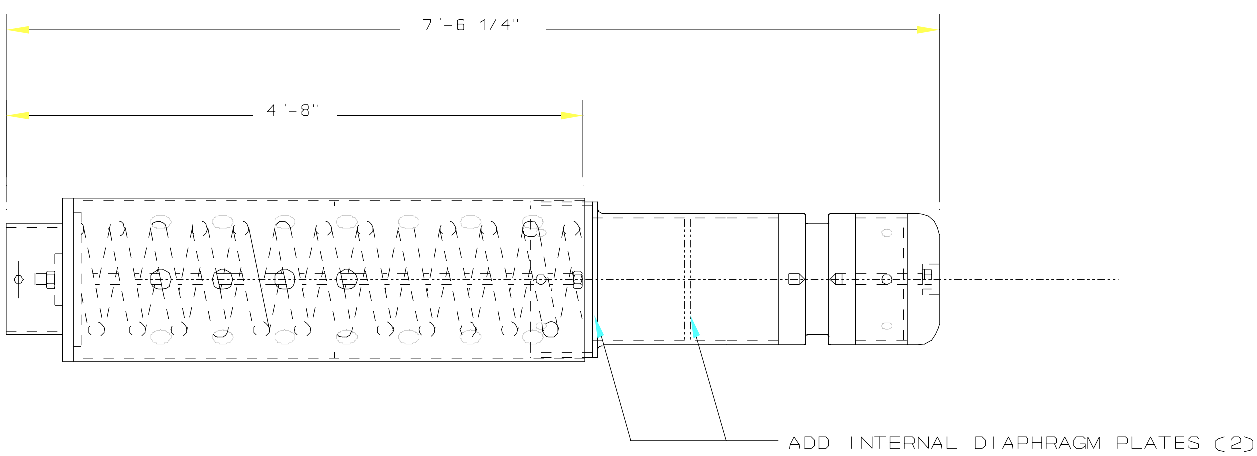
Notes:

- IWRC Mooring Wire Rope assumed.
- Two (2) cables per connection assumed.
- Cable diameters shown are based on upper-bound snap load with a factor of safety of 1.0.

Table 10.2-1
Connecting Cable Size Requirements

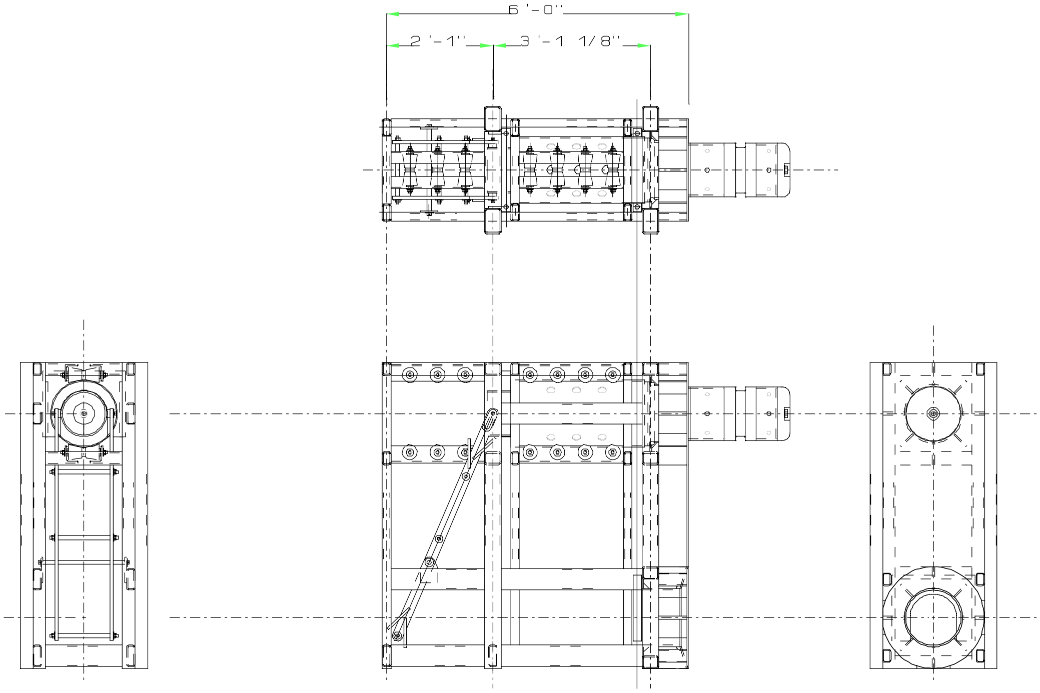


Revised "Shorter" Stabbing Pin Assembly

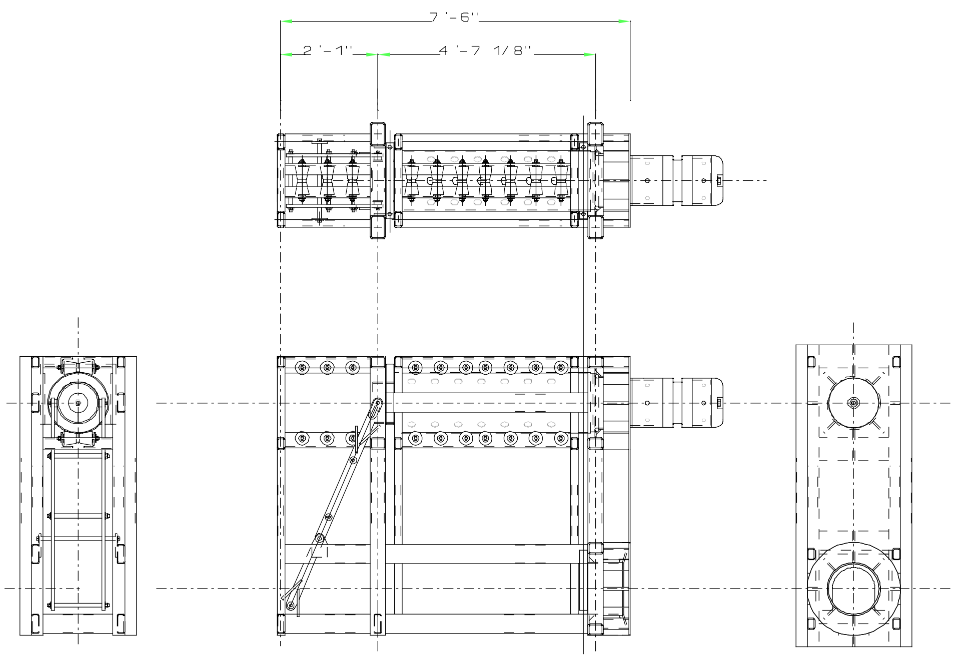


Revised "Longer" Stabbing Pin Assembly

Figure 10.3-1
Stabbing Pin Modifications



Assembly Frame Dimensions
w/ Shorter Stabbing Pin (no change)



Assembly Frame Dimensions
w/ Longer Stabbing Pin

Figure 10.4-1
Assembly Frame Geometry Modifications

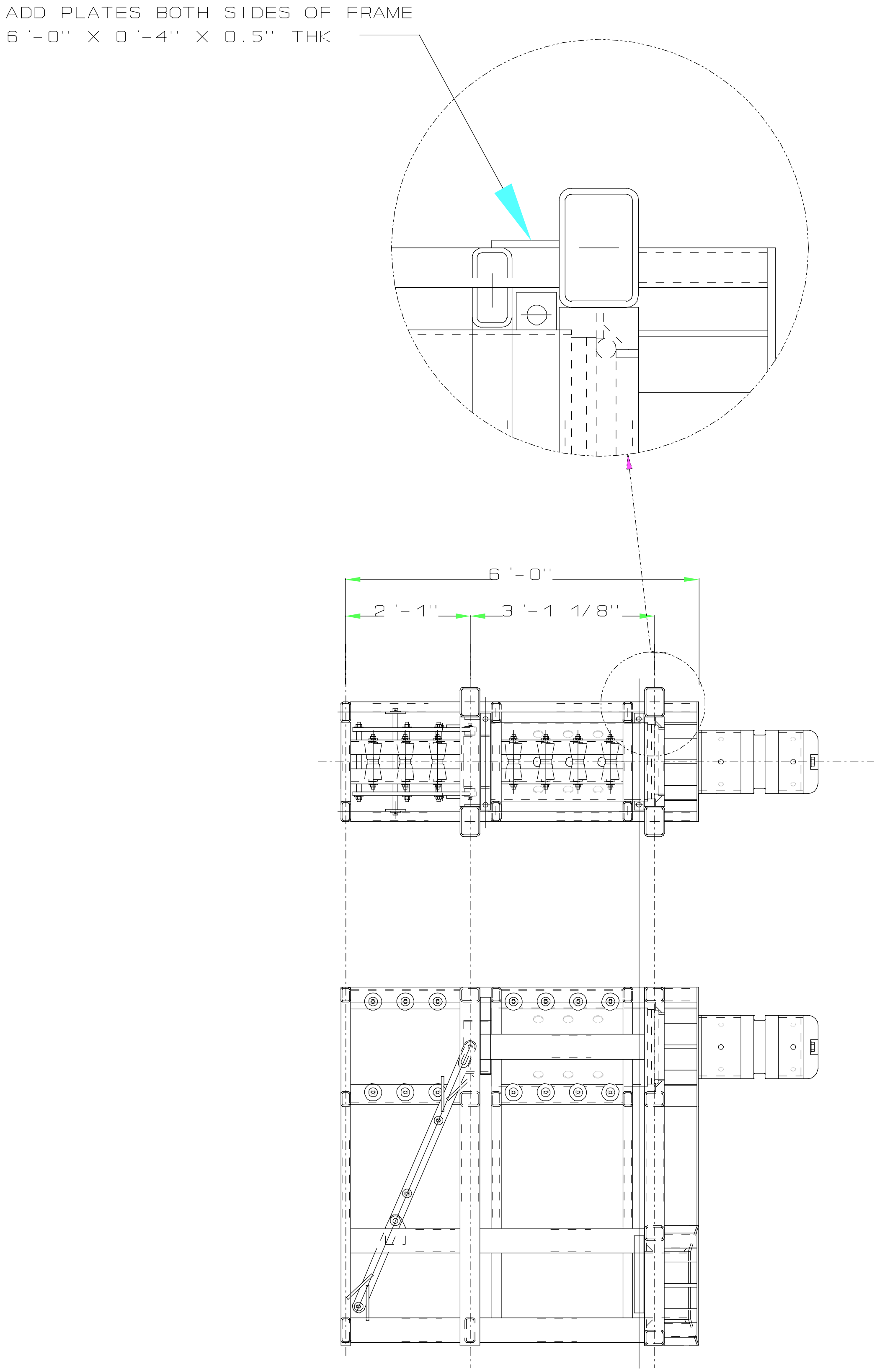
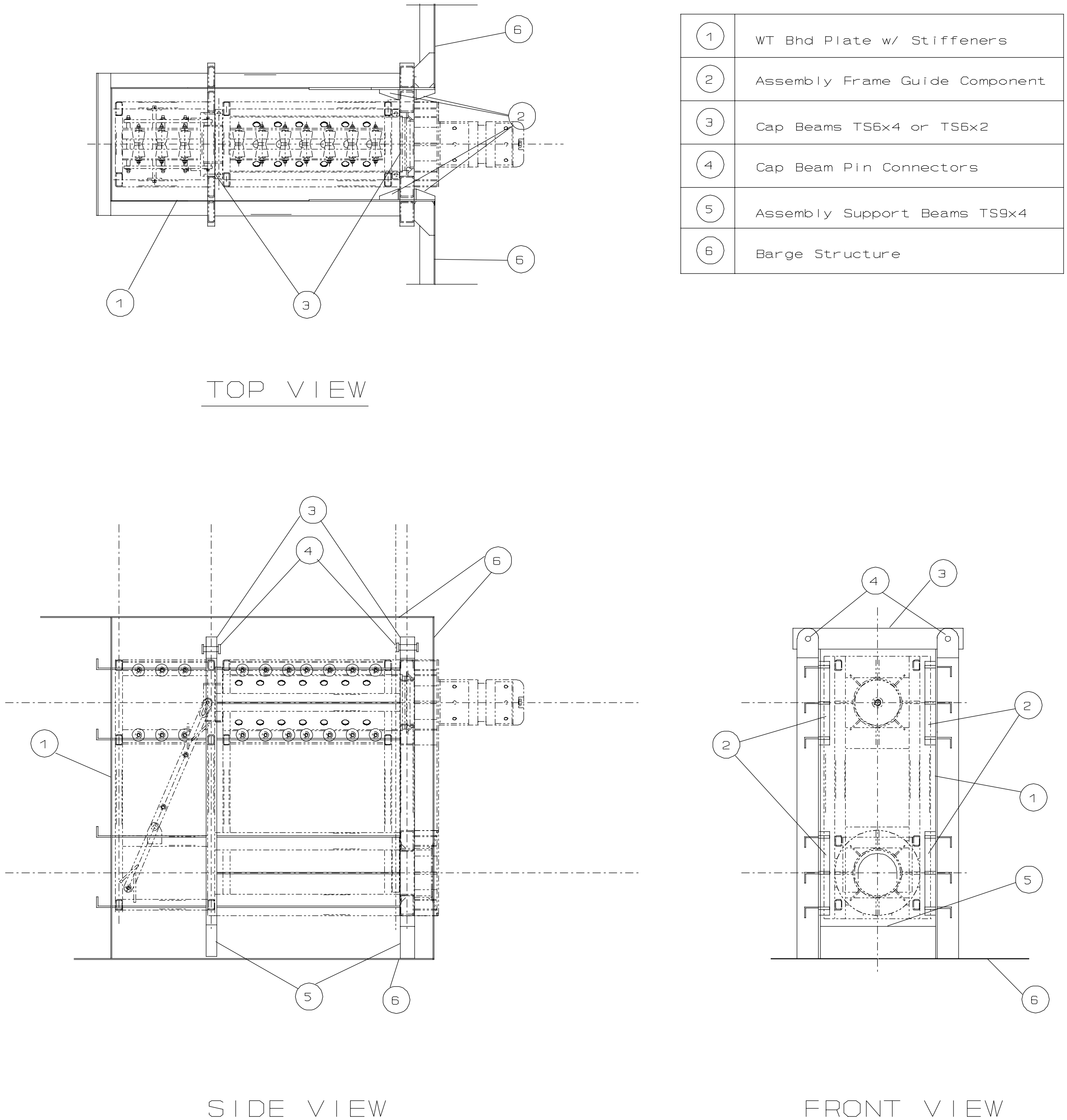


Figure 10.4-2
Assembly Frame Member Size Modifications



1	WT Bhd Plate w/ Stiffeners
2	Assembly Frame Guide Component
3	Cap Beams TS6x4 or TS6x2
4	Cap Beam Pin Connectors
5	Assembly Support Beams TS9x4
6	Barge Structure

Figure 10.5-1
Barge Connector Assembly Support Structure with Assembly Installed

11. REFERENCES

1. Huang, Erick T., "Conceptual Development of Open Sea Module Connection Techniques," TM-2067-AMP, March 1995.

2. Naval Facilities Engineering Services Command, Conceptual Design Drawings, NFESC Dwg. Nos. 95010001 through 95010005, August 1995.

3. I.D.E.A.S., Inc., "Review and Evaluation of Engineering Criteria," Technical Report on Task 20, 95701-TR-01, September 1995.

4. I.D.E.A.S., Inc., "Review and Evaluation of Government Alternative," Technical Report on Task 30, 95701-TR-02, October 1995.

5. I.D.E.A.S., Inc., "Development of Structural Layout for Selected Alternative," Technical Report on Task 40, 95701-TR-03, October 1995.

6. I.D.E.A.S., Inc., "Preliminary Design of Selected Alternative and Its Components," Technical Report on Task 50, 95701-TR-04, November 1995.

7. I.D.E.A.S., Inc., "Preliminary Design of Barge Support Structure for the Connection System," Technical Report on Task 60, 95701-TR-05, December 1995.

8. I.D.E.A.S., Inc., "Development of Materials List, Estimated Weights and Costs," Technical Report on Task 70, 95701-TR-06, December 1995.

9. I.D.E.A.S., Inc., "Development of Potential Modifications To System Components," Technical Report on Task 80, 95701-TR-07, December 1995.

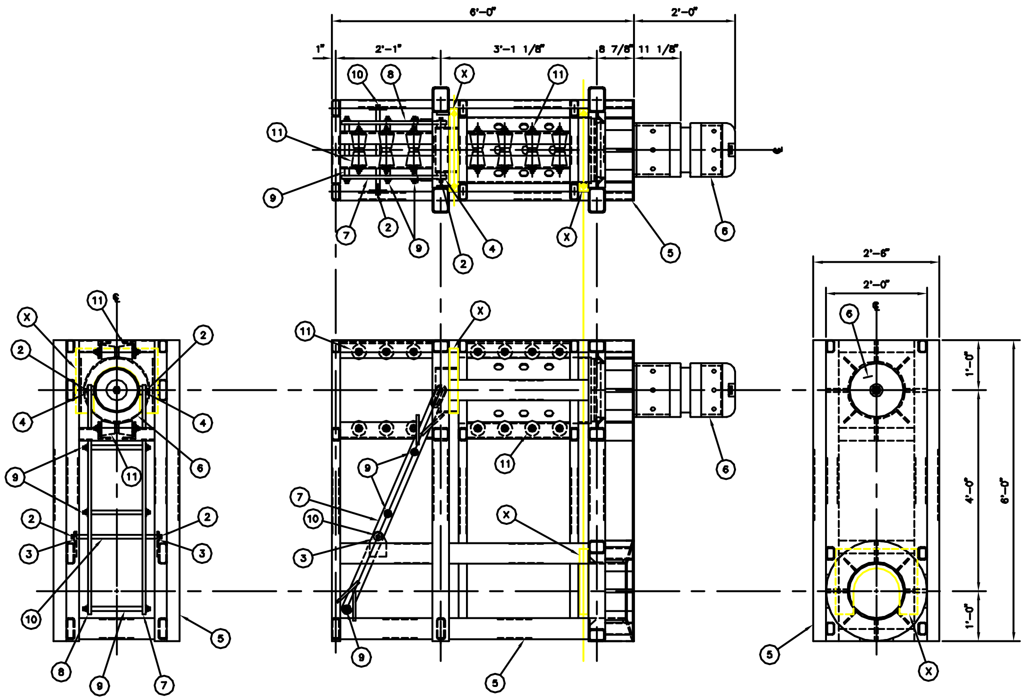
10. Webster, R.L. and Palo, P.A., "SEADYN90 User's Manual and Computer Program," NCEL Technical Note N-1803, November 1989.

11. Huang, S. and Vassalos, D., "Snap Loading of Marine Cables," Proceedings of the Fourth (1994) International Offshore and Polar Engineering Conference, ISOPE, Osaka, Japan, April 1994.

APPENDIX A

NFESC Concept Drawings

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL



(1) CONNECTOR ASSEMBLY

NOTES

1. ALL STRUCTURAL STEEL SHALL CONFORM TO ASTM SPECIFICATION A36 OF MOST RECENT ISSUE UNLESS OTHERWISE NOTED.
2. WELDING FOR STRUCTURAL STEEL SHALL CONFORM TO THE STRUCTURAL WELDING CODE, AWS D1.1 LATEST EDITION.
3. USE E70XX WELDING ROD OR AWS ER70S-2 WELDING WIRE WITH Ar-2% OXYGEN SHIELDING GAS FOR ALL WELDS.
4. REMOVE ALL ROUGH EDGES AND CORNERS ON ALL STEEL.
5. SEQUENCE OF WELDING SHALL BE SUCH AS TO MINIMIZE THE RESIDUAL STRESSES IN THE STEEL.
6. ALL GROOVE WELDS MUST HAVE THOROUGH PENETRATION AND ABSOLUTE FUSION.

-1	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL
X	13	95010001-13	X	
X	12	95010001-12	X	
14	11	95010005-11	ROLLER ASSEMBLY	
1	10	95010005-10	LEVER SHAFT	
3	9	95010005-6	LEVER ROD ASSEMBLY	
1	8	95010005-2	LEVER (OPP)	
1	7	95010005-1	LEVER (SHOWN)	
1	6	95010004-1	PIN ASSEMBLY	
1	5	95010002-1	FRAME	
2	4	95010001-4	WASHER, 2"OD X 13/16"ID X 5/32", ZINC PLATED	
2	3	95010001-3	WASHER, 2"OD X 1 1/16"ID X 9/64", ZINC PLATED	
4	2	95010001-2	SPRING PIN, 1/4"ø X 1 1/2" LG, BERYLLIUM COPPER	
X	1	95010001-1	CONNECTOR ASSEMBLY	

QUANTITY FOR EACH ASSEMBLY

PARTS LIST

PART DASH NO. | NEXT ASSY.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN FEET AND/OR INCHES

TOLERANCES:
.X DECIMALS
.XX DECIMALS
.XXX DECIMALS
FRACTIONS ±1/16"
ANGLES ±0.5°

PROJ NO
NFESC DWG. NO. 95010001
DES K.MACK | DR K.MACK 10/95
CHK F.DELLALIBERA
BRANCH HEAD K.MACK
DIV DIR
SATISFACTORY TO E.HUANG
APPROVED DATE
COMMANDING OFFICER
APPROVED DATE
FOR COMMANDER, NAVFAC

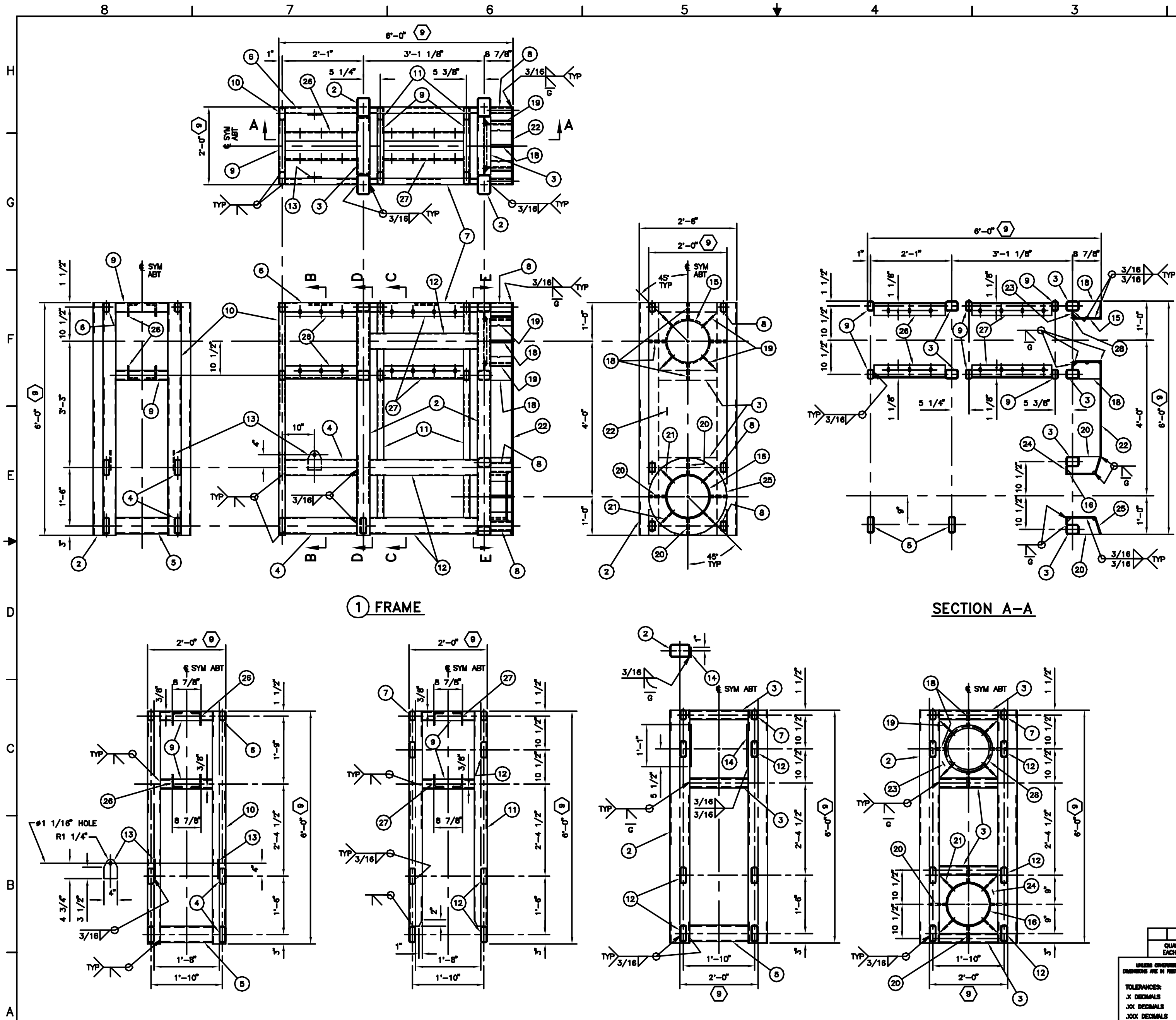
DEPARTMENT OF THE NAVY — NAVAL FACILITIES ENGINEERING COMMAND
NAVAL FACILITIES ENGINEERING SERVICE CENTER
PORT HUENEME, CALIFORNIA 93043

RIGID CONNECTION SYSTEM
RIGID CONNECTOR ASSEMBLY

SIZE F | CODE IDENT NO 80091 | NAVFAC DRAWING NO
CONSTR CONTR NO
SCALE NONE | SPEC | SHEET 1 OF 5

IF IN DOUBT, ASK — DO NOT SCALE

J95-10(310012)



1 FRAME

SECTION A-A

SECTION B-B

SECTION C-C

SECTION D-D

SECTION E-E

NOTES

1. ALL STRUCTURAL STEEL SHALL CONFORM TO ASTM SPECIFICATION A36 OF MOST RECENT ISSUE UNLESS OTHERWISE NOTED.
2. WELDING FOR STRUCTURAL STEEL SHALL CONFORM TO THE STRUCTURAL WELDING CODE, AWS D1.1 LATEST EDITION.
3. USE E70XX WELDING ROD OR AWS ER70S-2 WELDING WIRE WITH Ar-2% OXYGEN SHIELDING GAS FOR ALL WELDS.
4. REMOVE ALL ROUGH EDGES AND CORNERS ON ALL STEEL.
5. SEQUENCE OF WELDING SHALL BE SUCH AS TO MINIMIZE THE RESIDUAL STRESSES IN THE STEEL.
6. ALL GROOVE WELDS MUST HAVE THOROUGH PENETRATION AND ABSOLUTE FUSION.
7. ALL STRUCTURAL TUBING, TS, SHALL BE ASTM A500 GRADE B UNLESS NOTED OTHERWISE.
8. TUBING MAY BE FABRICATED BY ROLLING TO SIZE AND WELDING A FULL PENETRATION BUTT JOINT. GRIND FLUSH WITH THE INSIDE DIAMETER AND THE OUTSIDE DIAMETER TO PREVENT INTERFERENCE. (MAKE A SEAMLESS APPEARANCE)
9. NO MATERIAL SHALL EXTEND BEYOND THE WIDTH AND LENGTH DIMENSIONS OF THE CONNECTOR.

	-1	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL
	1	28	95010003-13	RING	
	4	27	95010003-12	ANGLE	
	4	26	95010003-11	ANGLE	
	1	25	95010003-10	FUNNEL PLATE	
	1	24	95010003-9	PLATE	
	1	23	95010003-8	PLATE	
	1	22	95010003-5	END PLATE ASSEMBLY	
	4	21	95010003-4	STIFFENER	
	4	20	95010003-3	STIFFENER	
	4	19	95010003-2	STIFFENER	
	4	18	95010003-1	STIFFENER	
8	1	16	95010002-16	TUBE 13 3/4" OD X 13" ID X 0'-8 7/8"	
8	1	15	95010002-15	TUBE 13 3/4" OD X 13" ID X 0'-7 5/8"	
	2	14	95010002-14	BAR 3" X 1/2" X 1'-1"	
	2	13	95010002-13	BAR 4" X 3/8" X 0'-6"	
	6	12	95010002-12	TS 5X2X.250 X 2'-9 1/8"	
	4	11	95010002-11	TS 4X2X.250 X 5'-6 1/2"	
	2	10	95010002-10	TS 4X2X.250 X 6'-0"	
	6	9	95010002-9	TS 3X2X.250 X 1'-4"	
	6	8	95010002-8	TS 3X2X.250 X 0'-6 1/2"	
	2	7	95010002-7	TS 3X2X.250 X 2'-9 1/8"	
	2	6	95010002-6	TS 3X2X.250 X 1'-10"	
	2	5	95010002-5	TS 5X2X.250 X 1'-4"	
	4	4	95010002-4	TS 5X2X.250 X 1'-10"	
	6	3	95010002-3	TS 4X3X.3125 X 1'-6"	
	4	2	95010002-2	TS 6X4X.3125 X 6'-0"	
	X	1	95010002-1	FRAME	

QUANTITY FOR EACH ASSEMBLY

PARTS LIST

PART DASH NO.	NEXT ASSY.
-1	95010001-1

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN FEET AND/OR INCHES

TOLERANCES:
.X DECIMALS
.XX DECIMALS
.XXX DECIMALS
FRACTIONS ±1/16"
ANGLES ±0.5°

PROJ NO
NFESC DWG. NO. 95010002
DES K.MACK | DR K.MACK 10/95
CHK F.DELLALIBERA
BRANCH HEAD K.MACK
DIV DIR
SATISFACTORY TO E.HUANG
APPROVED DATE
COMMANDING OFFICER
APPROVED DATE
FOR COMMANDER, NAVFAC

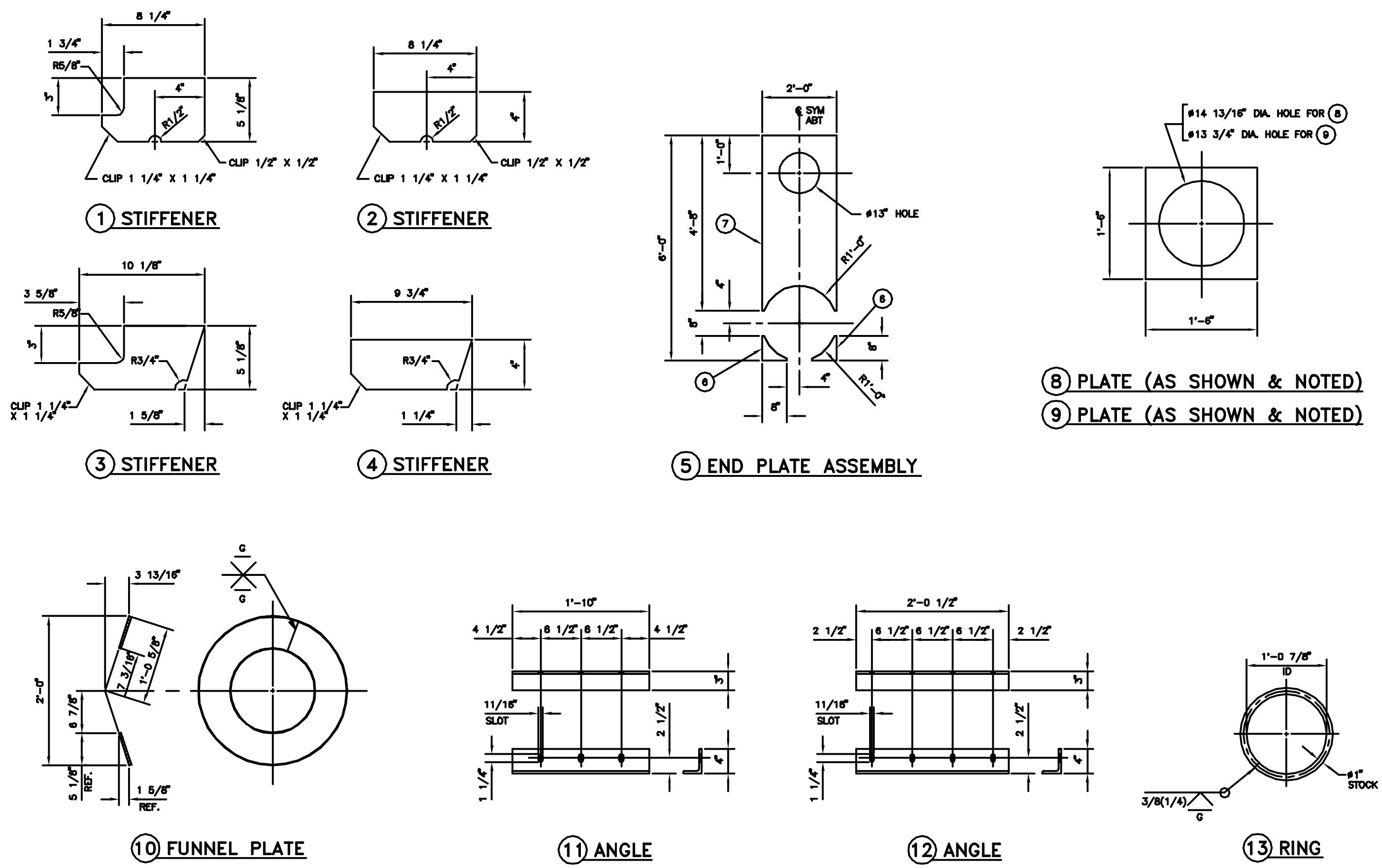
DEPARTMENT OF THE NAVY — NAVAL FACILITIES ENGINEERING COMMAND
NAVAL FACILITIES ENGINEERING SERVICE CENTER
PORT HUENEME, CALIFORNIA 93043

RIGID CONNECTION SYSTEM
RIGID CONNECTOR FRAME

SIZE F | CODE IDENT NO 80091 | NAVFAC DRAWING NO
CONSTR CONTR NO
SCALE NONE | SPEC | SHEET 2 OF 5

IF IN DOUBT, ASK - DO NOT SCALE

J95-10(310012)



NOTES

1. ALL STRUCTURAL STEEL SHALL CONFORM TO ASTM SPECIFICATION A36 OF MOST RECENT ISSUE UNLESS OTHERWISE NOTED.
2. WELDING FOR STRUCTURAL STEEL SHALL CONFORM TO THE STRUCTURAL WELDING CODE, AWS D1.1 LATEST EDITION.
3. USE E70XX WELDING ROD OR AWS ER70S-2 WELDING WIRE WITH Ar-2% OXYGEN SHIELDING GAS FOR ALL WELDS.
4. REMOVE ALL ROUGH EDGES AND CORNERS ON ALL STEEL.
5. SEQUENCE OF WELDING SHALL BE SUCH AS TO MINIMIZE THE RESIDUAL STRESSES IN THE STEEL.
6. ALL GROOVE WELDS MUST HAVE THOROUGH PENETRATION AND ABSOLUTE FUSION.

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

PARTS LIST

-5	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL
	13	95010003-13	RING, 1"⌀ X 3'-7 9/16", ROLL AS SHOWN	
	12	95010003-12	ANGLE, L 4X3X3/8 X 2'-0 1/2"	
	11	95010003-11	ANGLE, L 4X3X3/8 X 1'-10"	
	10	95010003-10	FUNNEL PLATE, 3/8" X 25 1/4" X 2'-1 1/4", ROLL	
	9	95010003-9	PLATE, 3/8" X 18" X 1'-6"	
	8	95010003-8	PLATE, 3/8" X 18" X 1'-6"	
1	7	95010003-7	PLATE 3/8" X" X 4'-8"	
2	6	95010003-6	BAR 8" X 3/8" X 0'-8"	
X	5	95010003-5	END PLATE ASSEMBLY	
	4	95010003-4	STIFFENER, BAR 4" X 3/8" X 0'-9 3/4"	
	3	95010003-3	STIFFENER, BAR 5 1/8" X 3/4" X 0'-10 1/8"	
	2	95010003-2	STIFFENER, BAR 4" X 3/8" X 0'-8 1/4"	
	1	95010003-1	STIFFENER, BAR 5 1/8" X 3/4" X 0'-8 1/4"	

QUANTITY FOR EACH ASSEMBLY

PART DASH NO.	NEXT ASSY.
ALL	95010002-1

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN FEET AND/OR INCHES

TOLERANCES:
.X DECIMALS
.XX DECIMALS
.XXX DECIMALS
FRACTIONS ±1/16"
ANGLES ±0.5°

PROJ NO
NFESC DWG. NO. 95010003
DES K.MACK | DR K.MACK 10/95
CHK F.DELLALIBERA
BRANCH HEAD K.MACK
DIV DIR
SATISFACTORY TO E.HUANG
APPROVED DATE
COMMANDING OFFICER
APPROVED DATE
FOR COMMANDER, NAVFAC

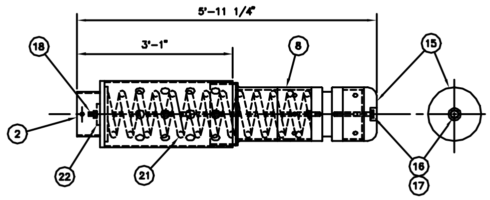
DEPARTMENT OF THE NAVY NAVAL FACILITIES ENGINEERING COMMAND
NAVAL FACILITIES ENGINEERING SERVICE CENTER
PORT HUENEME, CALIFORNIA 93043

RIGID CONNECTION SYSTEM
RIGID CONNECTOR FRAME DETAILS

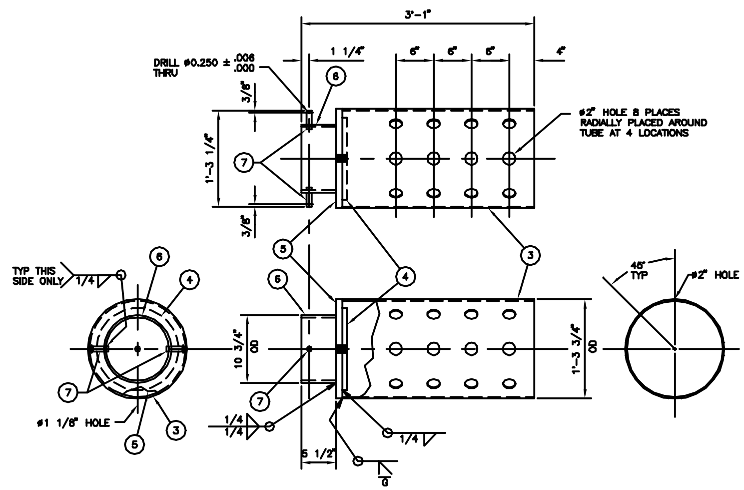
SIZE F | CODE IDENT NO 80091 | NAVFAC DRAWING NO
CONSTR CONTR NO
SCALE NONE | SPEC | SHEET 3 OF 5

IF IN DOUBT, ASK - DO NOT SCALE

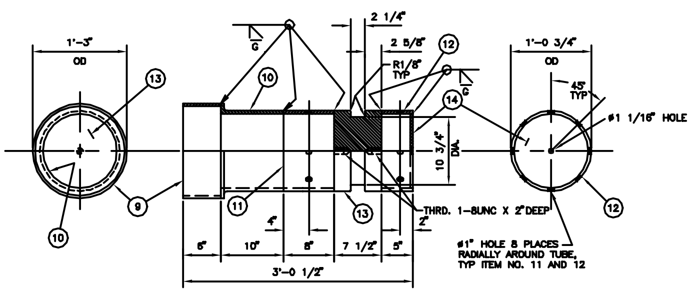
J95-10(310012)



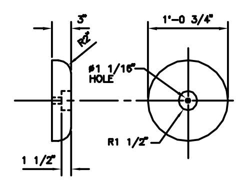
1 PIN ASSEMBLY



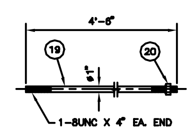
2 PIN CASE



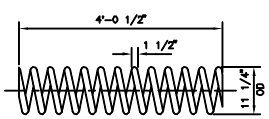
8 NOSE



15 CAP

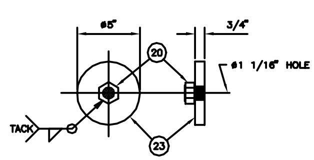


18 PIN ROD



21 SPRING

7



22 PIN PLATE

NOTES

1. ALL STRUCTURAL STEEL SHALL CONFORM TO ASTM SPECIFICATION A36 OF MOST RECENT ISSUE UNLESS OTHERWISE NOTED.
2. WELDING FOR STRUCTURAL STEEL SHALL CONFORM TO THE STRUCTURAL WELDING CODE, AWS D1.1 LATEST EDITION.
3. USE E70XX WELDING ROD OR AWS ER70S-2 WELDING WIRE WITH Ar-2% OXYGEN SHIELDING GAS FOR ALL WELDS.
4. REMOVE ALL ROUGH EDGES AND CORNERS ON ALL STEEL.
5. SEQUENCE OF WELDING SHALL BE SUCH AS TO MINIMIZE THE RESIDUAL STRESSES IN THE STEEL.
6. ALL GROOVE WELDS MUST HAVE THOROUGH PENETRATION AND ABSOLUTE FUSION.
7. THE COMPRESSION SPRING SHALL HAVE THE FOLLOWING SPECIFICATIONS:
   - WIRE DIAMETER 1 1/2"
   - INSIDE DIAMETER 8 1/4"
   - OUTSIDE DIAMETER 11 1/4"
   - FREE LENGTH 48 1/2"
   - MATERIAL/FINISH SAE 5160H/ ZINC COATED
   - DEFLECTION AT 15000 LBS. 24"
   - ENDS - SQUARED AND GROUND
8. TUBING MAY BE FABRICATED BY ROLLING TO SIZE AND WELDING A FULL PENETRATION BUTT JOINT. GRIND FLUSH WITH THE INSIDE DIAMETER AND THE OUTSIDE DIAMETER TO PREVENT INTERFERENCE. (MAKE A SEAMLESS APPEARANCE)

REVISIONS

SYM	DESCRIPTION	DATE	APPROVAL

PARTS LIST

	-22	-18	-8	-2	-1	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL
	1					23	95010004-23	BAR 5"ø X 0'-0 3/4"	
	X				1	22	95010004-22	PIN PLATE	
7.					1	21	95010004-21	SPRING	
	1	1				20	95010004-20	NUT, 1-8UNC, HEX, ZINC CHROMATE, SAE GR.2	
		1				19	95010004-19	BAR 1"ø X 4'-6"	
		X			1	18	95010004-18	PIN ROD	
					1	17	95010004-17	WASHER, 2"OD X 1 1/16"ID X 9/64", ZINC PLATED	
					1	16	95010004-16	CAP SCREW, 1-8UNC X 0'-8", HEX HEAD, ZINC PLATED, SAE GR.2	
					1	15	95010004-15	CAP, 12 3/4"ø X 0'-3", MACHINE,	TYPE 1 POLYVINYL CHLORIDE (PVC)
			1			14	95010004-14	BAR 11 3/4"ø X 0'-0 3/8"	
			1			13	95010004-13	BAR 12 3/4"ø X 0'-7 1/2", MACHINE AS SHOWN	
			1			12	95010004-12	TUBE 12 3/4"OD X 11 3/4"ID X 0'-5", HOT FINISHED SEAMLESS, ASTM A53 GR.B	
			1			11	95010004-11	TUBE 12 3/4"OD X 11 3/4"ID X 0'-8", HOT FINISHED SEAMLESS, ASTM A53 GR.B	
			1			10	95010004-10	LAP JOINT STUB END, 12" PIPE SIZE, X-STRONG, ASTM A234, SEAMLESS WELDING FITTING	
8.			1			9	95010004-9	TUBE 15"OD X 14 1/4"ID X 0'-6"	
			X		1	8	95010004-8	NOSE	
				2		7	95010004-7	BAR 3/4"ø X 0'-3"	
8.				1		6	95010004-6	TUBE 10 3/4"OD X 10"ID X 0'-5 1/2"	
				1		5	95010004-5	BAR 15 3/4"ø X 0'-1"	
				1		4	95010004-4	BAR 13"ø X 0'-0 3/4"	
8.				1		3	95010004-3	TUBE 15 3/4"OD X 15 1/4"ID X 2'-6 1/2"	
				X	1	2	95010004-2	PIN CASE	
					X	1	95010004-1	PIN ASSEMBLY	

QUANTITY FOR EACH ASSEMBLY

PART DASH NO.	NEXT ASSY.
-1	95010001-1

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN FEET AND/OR INCHES

TOLERANCES:
.X DECIMALS
.XX DECIMALS
.XXX DECIMALS
FRACTIONS ±1/16"
ANGLES ±0.5°

PROJ NO
NFESC DWG. NO. 95010004
DES K.MACK | DR K.MACK 10/95
CHK F.DELLALIBERA
BRANCH HEAD K.MACK
DIV DIR
SATISFACTORY TO E.HUANG
APPROVED DATE
COMMANDING OFFICER
APPROVED DATE
FOR COMMANDER, NAVFAC

DEPARTMENT OF THE NAVY — NAVAL FACILITIES ENGINEERING COMMAND
NAVAL FACILITIES ENGINEERING SERVICE CENTER
PORT HUENEME, CALIFORNIA 93043

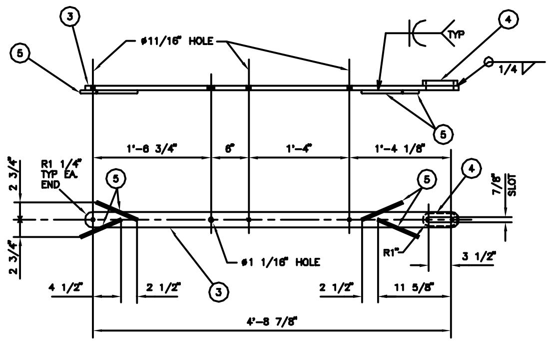
RIGID CONNECTION SYSTEM
RIGID CONNECTOR
PIN ASSEMBLY

SIZE F | CODE IDENT NO 80091 | NAVFAC DRAWING NO
CONSTR CONTR NO
SCALE NONE | SPEC | SHEET 4 OF 5

IF IN DOUBT, ASK - DO NOT SCALE

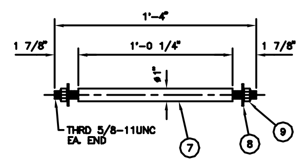
J95-10(310012)

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVAL

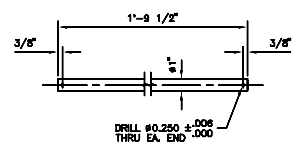


(1) LEVER (SHOWN)

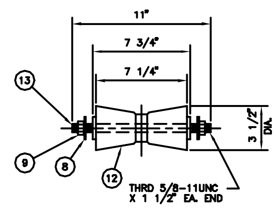
(2) LEVER (OPP.)



(6) LEVER ROD ASSEMBLY



(10) LEVER SHAFT



(11) ROLLER ASSEMBLY

NOTES

1. ALL STRUCTURAL STEEL SHALL CONFORM TO ASTM SPECIFICATION A36 OF MOST RECENT ISSUE UNLESS OTHERWISE NOTED.
2. WELDING FOR STRUCTURAL STEEL SHALL CONFORM TO THE STRUCTURAL WELDING CODE, AWS D1.1 LATEST EDITION.
3. USE E70XX WELDING ROD OR AWS ER70S-2 WELDING WIRE WITH Ar-2% OXYGEN SHIELDING GAS FOR ALL WELDS.
4. REMOVE ALL ROUGH EDGES AND CORNERS ON ALL STEEL.
5. SEQUENCE OF WELDING SHALL BE SUCH AS TO MINIMIZE THE RESIDUAL STRESSES IN THE STEEL.
6. ALL GROOVE WELDS MUST HAVE THOROUGH PENETRATION AND ABSOLUTE FUSION.

-11	-6	-2	-1	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL
1				13	95010005-13	BAR 5/8"ø X 0'-11"	
1				12	95010005-12	KEEL ROLLER, 8" NOM., RUBBER, STL SLEEVES, NYLON BUSHINGS	
X				11	95010005-11	ROLLER ASEMBLY	
				10	95010005-10	LEVER SHAFT, BAR 1"ø X 1'-9 1/2"	
2	2			9	95010005-9	NUT, 5/8-11UNC, HEX, ZINC CHROMATE, SAE GR.2	
2	2			8	95010005-8	WASHER, 1 3/4"OD X 11/16"ID X 9/64", ZINC PLATED	
	1			7	95010005-7	BAR 1"ø X 1'-4"	
	X			6	95010005-6	LEVER ROD ASSEMBLY	
		4	4	5	95010005-5	BAR 1/2"ø X 0'-7"	
		1	1	4	95010005-4	BAR 2" X 3/4" X 0'-5 1/2"	
		1	1	3	95010005-3	BAR 2 1/2" X 3/4" X 4'-11 3/8"	
		X		2	95010005-2	LEVER	
			X	1	95010005-1	LEVER	
QUANTITY FOR EACH ASSEMBLY				PARTS LIST			

PART DASH NO.	NEXT ASSY.
-11	95010001-1
-6	95010001-1
-2	95010001-1
-1	95010001-1

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN FEET AND/OR INCHES

TOLERANCES:
.X DECIMALS
.XX DECIMALS
.XXX DECIMALS
FRACTIONS ±1/16"
ANGLES ±0.5°

PROJ NO
NFESC DWG. NO. 95010005
DES K.MACK | DR K.MACK 10/95
CHK F.DELLALIBERA
BRANCH HEAD K.MACK
DIV DIR
SATISFACTORY TO E.HUANG
APPROVED DATE
COMMANDING OFFICER
APPROVED DATE
FOR COMMANDER, NAVFAC

DEPARTMENT OF THE NAVY NAVAL FACILITIES ENGINEERING COMMAND
NAVAL FACILITIES ENGINEERING SERVICE CENTER
PORT HUENEME, CALIFORNIA 93043

RIGID CONNECTION SYSTEM
RIGID CONNECTOR
LEVER & ROLLER DETAILS

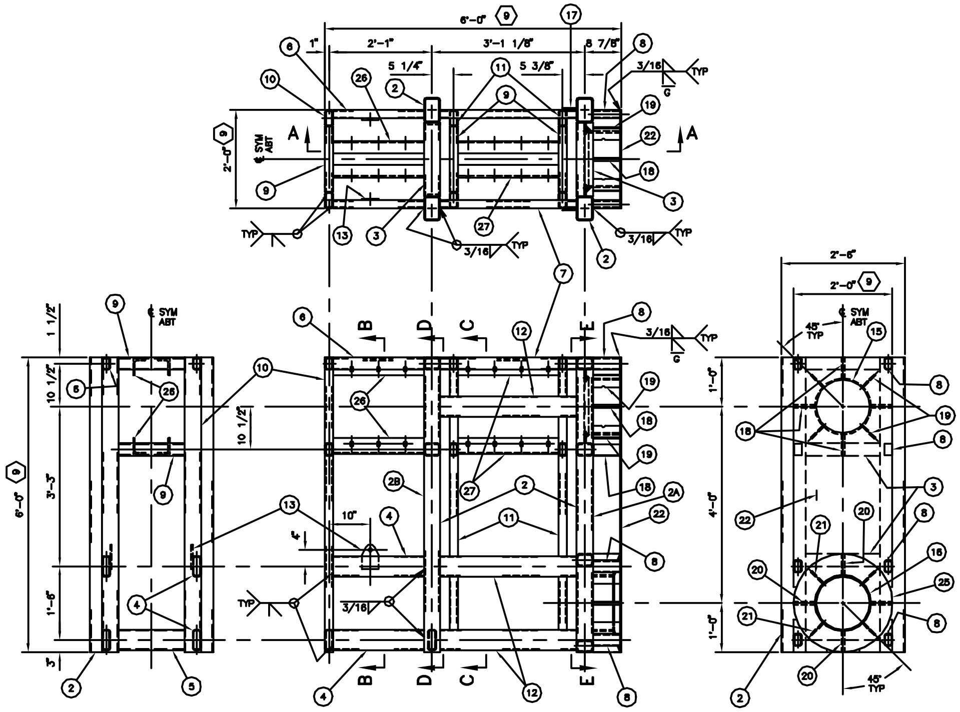
SIZE F | CODE IDENT NO 80091 | NAVFAC DRAWING NO
CONSTR CONTR NO
SCALE NONE | SPEC | SHEET 5 OF 5

IF IN DOUBT, ASK – DO NOT SCALE

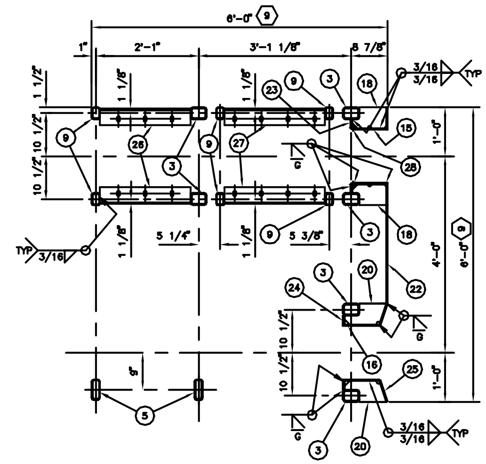
J95-10(310012)

APPENDIX B

Revised Concept Drawings



1 FRAME



SECTION A–A

NOTES

1. ALL STRUCTURAL STEEL SHALL CONFORM TO ASTM SPECIFICATION A36 OF MOST RECENT ISSUE UNLESS OTHERWISE NOTED.
2. WELDING FOR STRUCTURAL STEEL SHALL CONFORM TO THE STRUCTURAL WELDING CODE, AWS D1.1 LATEST EDITION.
3. USE E70XX WELDING ROD OR AWS ER70S–2 WELDING WIRE WITH Ar–2% OXYGEN SHIELDING GAS FOR ALL WELDS.
4. REMOVE ALL ROUGH EDGES AND CORNERS ON ALL STEEL.
5. SEQUENCE OF WELDING SHALL BE SUCH AS TO MINIMIZE THE RESIDUAL STRESSES IN THE STEEL.
6. ALL GROOVE WELDS MUST HAVE THOROUGH PENETRATION AND ABSOLUTE FUSION.

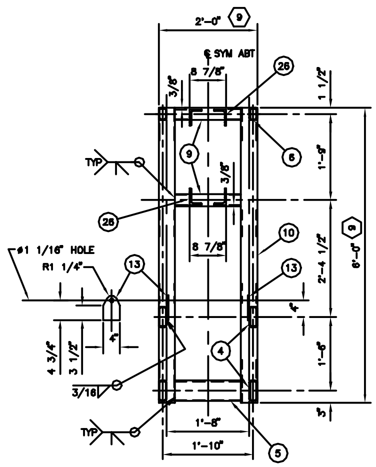
10. 7. ALL STRUCTURAL TUBING, TS, SHALL BE ASTM A572 GRADE 50 UNLESS NOTED OTHERWISE.

8. TUBING MAY BE FABRICATED BY ROLLING TO SIZE AND WELDING A FULL PENETRATION BUTT JOINT. GRIND FLUSH WITH THE INSIDE DIAMETER AND THE OUTSIDE DIAMETER TO PREVENT INTERFERENCE. (MAKE A SEAMLESS APPEARANCE)

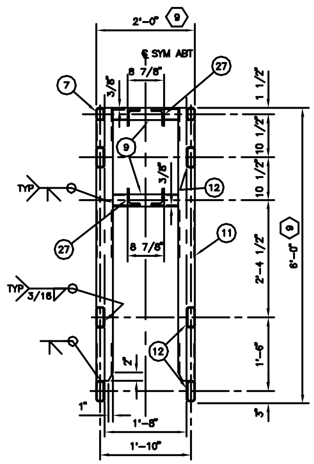
9. NO MATERIAL SHALL EXTEND BEYOND THE WIDTH AND LENGTH DIMENSIONS OF THE CONNECTOR.

10. I.D.E.A.S. PROPOSED MODIFICATIONS SHOWN IN MATERIALS LIST BELOW. DO NOT SCALE DIMENSIONS OR SIZES FROM DRAWING.

	1	28	95010003–13	RING
	4	27	95010003–12	ANGLE
	4	26	95010003–11	ANGLE
	1	25	95010003–10	FUNNEL PLATE
	1	24	95010003–9	PLATE
	1	23	95010003–8	PLATE
	1	22	95010003–5	END PLATE ASSEMBLY
	4	21	95010003–4	STIFFENER
	4	20	95010003–3	STIFFENER
	4	19	95010003–2	STIFFENER
	4	18	95010003–1	STIFFENER
10.	2	17	95010002–17	BAR 3" X 1/2" X 6'–0"
10. 8.	1	16	95010002–16	TUBE 14 1/8"OD X 13 3/8"ID X 0'–8 7/8"
10. 8.	1	15	95010002–15	TUBE 14 1/8"OD X 13 3/8"ID X 0'–7 5/8"
	2	14	95010002–14	BAR 3" X 1/2" X 1'–1"
	2	13	95010002–13	BAR 4" X 3/8" X 0'–6"
10.	4	12	95010002–12	TS 5X2X.250 X 2'–9 1/8"
	4	11	95010002–11	TS 4X2X.250 X 5'–6 1/2"
10.	2	10	95010002–10	TS 3X2X.250 X 6'–0"
	6	9	95010002–9	TS 3X2X.250 X 1'–4"
10.	8	8	95010002–8	TS 3X2X.250 X 0'–6 1/2"
10.	2	7	95010002–7	TS 6X2X.375 X 2'–9 1/8"
	2	6	95010002–6	TS 3X2X.250 X 1'–10"
10.	2	5	95010002–5	TS 3X2X.250 X 1'–4"
10.	4	4	95010002–4	TS 3X2X.250 X 1'–10"
10.	6	3	95010002–3	TS 3X2X.250 X 1'–6"
10.	2	2B	95010002–2	TS 6X2X.375 X 6'–0"
10.	2	2A	95010002–2	TS 6X4X.500X 6'–0"
		1	95010002–1	FRAME



SECTION B–B



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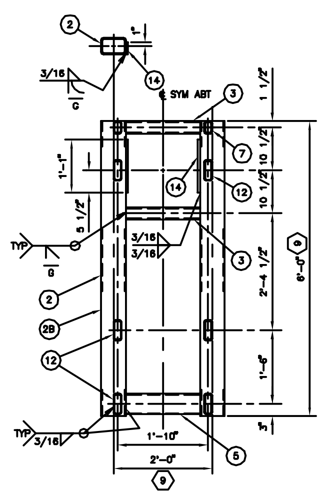
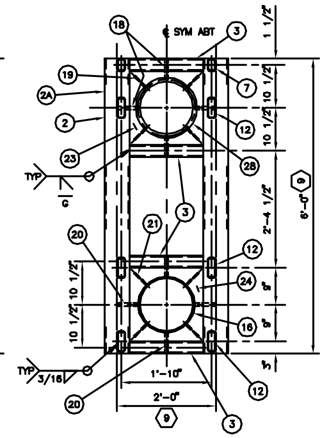


SECTION D–D



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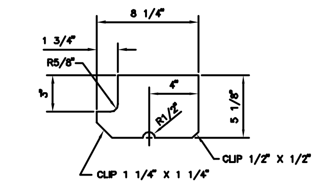
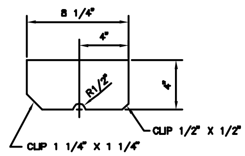
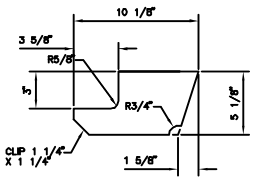


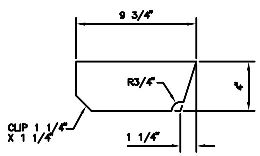
1 STIFFENER



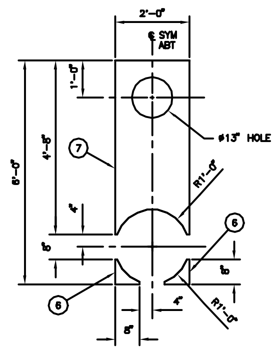
2 STIFFENER



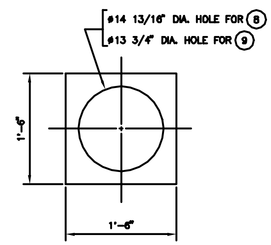
3 STIFFENER



4 STIFFENER



5 END PLATE ASSEMBLY

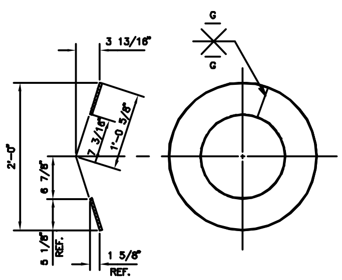


8 PLATE (AS SHOWN & NOTED)

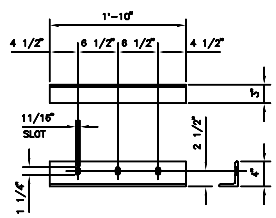
9 PLATE (AS SHOWN & NOTED)

NOTES

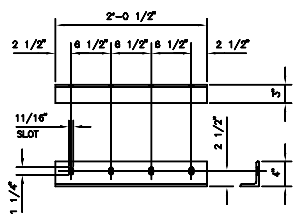
1. ALL STRUCTURAL STEEL SHALL CONFORM TO ASTM SPECIFICATION A36 OF MOST RECENT ISSUE UNLESS OTHERWISE NOTED.
2. WELDING FOR STRUCTURAL STEEL SHALL CONFORM TO THE STRUCTURAL WELDING CODE, AWS D1.1 LATEST EDITION.
3. USE E70XX WELDING ROD OR AWS ER70S-2 WELDING WIRE WITH Ar-2% OXYGEN SHIELDING GAS FOR ALL WELDS.
4. REMOVE ALL ROUGH EDGES AND CORNERS ON ALL STEEL.
5. SEQUENCE OF WELDING SHALL BE SUCH AS TO MINIMIZE THE RESIDUAL STRESSES IN THE STEEL.
6. ALL GROOVE WELDS MUST HAVE THOROUGH PENETRATION AND ABSOLUTE FUSION.
7. I.D.E.A.S. PROPOSES NO REVISIONS TO THIS DRAWING (95010003).



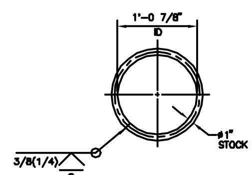
10 FUNNEL PLATE



11 ANGLE

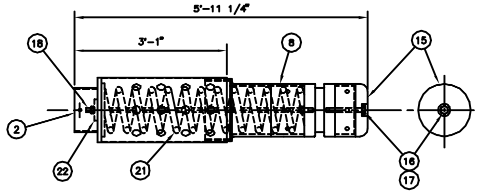


12 ANGLE

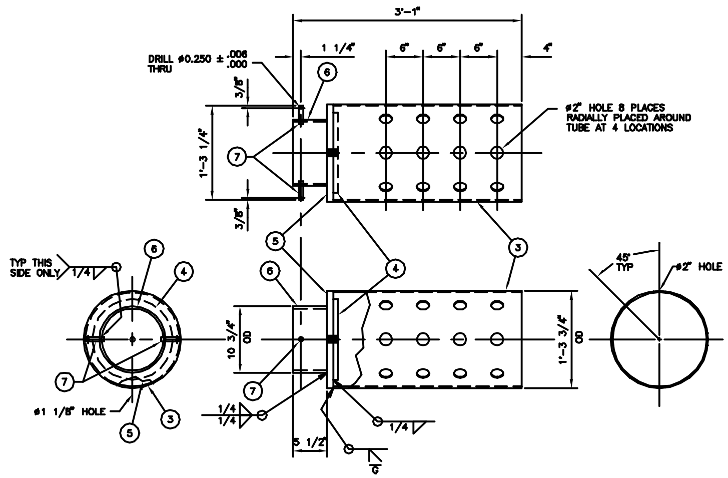


13 RING

	13	95010003-13	RING, 1"ø X 3'-7 9/16", ROLL AS SHOWN
	12	95010003-12	ANGLE, L 4X3X3/8 X 2'-0 1/2"
	11	95010003-11	ANGLE, L 4X3X3/8 X 1'-10"
	10	95010003-10	FUNNEL PLATE, 3/8" X 25 1/4" X 2'-1 1/4", ROLL
	9	95010003-9	PLATE, 3/8" X 18" X 1'-6"
	8	95010003-8	PLATE, 3/8" X 18" X 1'-6"
1	7	95010003-7	PLATE 3/8" X" X 4'-8"
2	6	95010003-6	BAR 8" X 3/8" X 0'-8"
X	5	95010003-5	END PLATE ASSEMBLY
	4	95010003-4	STIFFENER, BAR 4" X 3/8" X 0'-9 3/4"
	3	95010003-3	STIFFENER, BAR 5 1/8" X 3/4" X 0'-10 1/8"
	2	95010003-2	STIFFENER, BAR 4" X 3/8" X 0'-8 1/4"
	1	95010003-1	STIFFENER, BAR 5 1/8" X 3/4" X 0'-8 1/4"



1 PIN ASSEMBLY



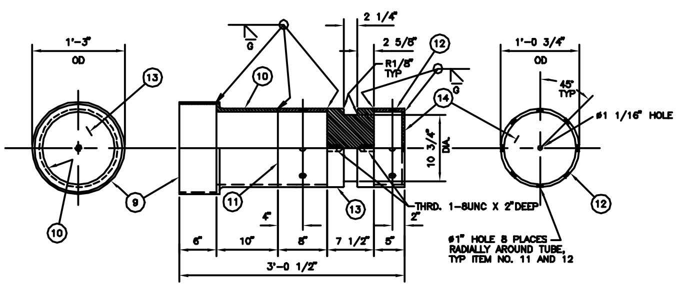
2 PIN CASE

NOTES

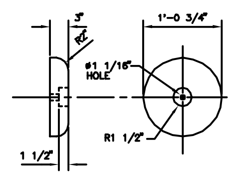
1. ALL STRUCTURAL STEEL SHALL CONFORM TO ASTM SPECIFICATION A36 OF MOST RECENT ISSUE UNLESS OTHERWISE NOTED.
2. WELDING FOR STRUCTURAL STEEL SHALL CONFORM TO THE STRUCTURAL WELDING CODE, AWS D1.1 LATEST EDITION.
3. USE E70XX WELDING ROD OR AWS ER70S-2 WELDING WIRE WITH Ar-2% OXYGEN SHIELDING GAS FOR ALL WELDS.
4. REMOVE ALL ROUGH EDGES AND CORNERS ON ALL STEEL.
5. SEQUENCE OF WELDING SHALL BE SUCH AS TO MINIMIZE THE RESIDUAL STRESSES IN THE STEEL.
6. ALL GROOVE WELDS MUST HAVE THOROUGH PENETRATION AND ABSOLUTE FUSION.
7. THE COMPRESSION SPRING SHALL HAVE THE FOLLOWING SPECIFICATIONS:

WIRE DIAMETER	1 1/2"
INSIDE DIAMETER	8 1/4"
OUTSIDE DIAMETER	11 1/4"
FREE LENGTH	48 1/2"
MATERIAL/FINISH	SAE 5160H/ ZINC COATED
DEFLECTION AT 15000 LBS.	24"
ENDS – SQUARED AND GROUND	

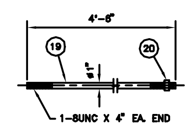
8. TUBING MAY BE FABRICATED BY ROLLING TO SIZE AND WELDING A FULL PENETRATION BUTT JOINT. GRIND FLUSH WITH THE INSIDE DIAMETER AND THE OUTSIDE DIAMETER TO PREVENT INTERFERENCE. (MAKE A SEAMLESS APPEARANCE)
9. I.D.E.A.S. PROPOSED REVISIONS ARE TO CHANGE MATERIAL STRENGTH TO HIGH STRENGTH (FY=50 KSI) STEEL AND INCREASE THE WALL THICKNESS OF ITEMS 10 AND 11.



8 NOSE

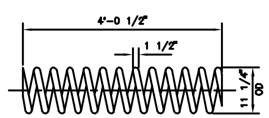


15 CAP

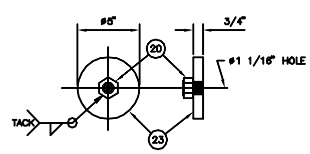


18 PIN ROD

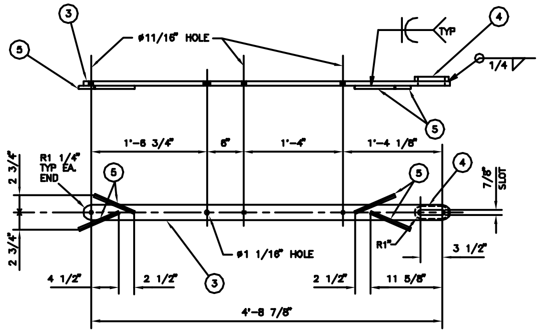
	1					23	95010004-23	BAR 5"ø X 0'-0 3/4"
	X				1	22	95010004-22	PIN PLATE
7.					1	21	95010004-21	SPRING
	1	1				20	95010004-20	NUT, 1-8UNC, HEX, ZINC CHROMATE, SAE GR.2
		1				19	95010004-19	BAR 1"ø X 4'-6"
		X			1	18	95010004-18	PIN ROD
					1	17	95010004-17	WASHER, 2"OD X 1 1/16"ID X 9/64", ZINC PLATED
					1	16	95010004-16	CAP SCREW, 1-8UNC X 0'-8", HEX HEAD, ZINC PLATED, SAE GR.2
					1	15	95010004-15	CAP, 12 3/4"ø X 0'-3", MACHINE. TYPE 1 POLYVINYL CHLORIDE (PVC)
			1			14	95010004-14	BAR 11 3/4"ø X 0'-0 3/8"
			1			13	95010004-13	BAR 12 3/4"ø X 0'-7 1/2", MACHINE AS SHOWN
			1			12	95010004-12	TUBE 12 3/4"OD X 11 3/4"ID X 0'-5", HOT FINISHED SEAMLESS, ASTM A53 GR.B
9.			1			11	95010004-11	TUBE 12 3/4"OD X 11"ID X 0'-8", HOT FINISHED SEAMLESS, ASTM A572 GR.50
9.			1			10	95010004-10	TUBE 12 3/4"OD X 11"ID X 0'-10", HOT FINISHED SEAMLESS, ASTM A572 GR.50
8.			1			9	95010004-9	TUBE 15"OD X 14 1/4"ID X 0'-6"
			X		1	8	95010004-8	NOSE
				2		7	95010004-7	BAR 3/4"ø X 0'-3"
8.				1		6	95010004-6	TUBE 10 3/4"OD X 10"ID X 0'-5 1/2"
				1		5	95010004-5	BAR 15 3/4"ø X 0'-1"
				1		4	95010004-4	BAR 13"ø X 0'-0 3/4"
8.				1		3	95010004-3	TUBE 15 3/4"OD X 15 1/4"ID X 2'-6 1/2"
				X	1	2	95010004-2	PIN CASE
					X	1	95010004-1	PIN ASSEMBLY



21 SPRING
7

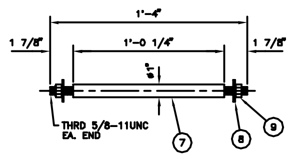


22 PIN PLATE

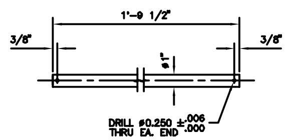


1 LEVER (SHOWN)

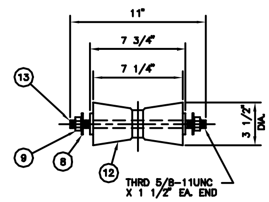
2 LEVER (OPP.)



6 LEVER ROD ASSEMBLY



10 LEVER SHAFT



11 ROLLER ASSEMBLY

NOTES

1. ALL STRUCTURAL STEEL SHALL CONFORM TO ASTM SPECIFICATION A36 OF MOST RECENT ISSUE UNLESS OTHERWISE NOTED.
2. WELDING FOR STRUCTURAL STEEL SHALL CONFORM TO THE STRUCTURAL WELDING CODE, AWS D1.1 LATEST EDITION.
3. USE E70XX WELDING ROD OR AWS ER70S-2 WELDING WIRE WITH Ar-2% OXYGEN SHIELDING GAS FOR ALL WELDS.
4. REMOVE ALL ROUGH EDGES AND CORNERS ON ALL STEEL.
5. SEQUENCE OF WELDING SHALL BE SUCH AS TO MINIMIZE THE RESIDUAL STRESSES IN THE STEEL.
6. ALL GROOVE WELDS MUST HAVE THOROUGH PENETRATION AND ABSOLUTE FUSION.
7. I.D.E.A.S. PROPOSES NO REVISIONS FOR THIS DRAWING (95010005).

1				13	95010005-13	BAR 5/8"ø X 0'-11"
1				12	95010005-12	KEEL ROLLER, 8" NOM., RUBBER, STL SLEEVES, NYLON BUSHINGS
X				11	95010005-11	ROLLER ASEMBLY
				10	95010005-10	LEVER SHAFT, BAR 1"ø X 1'-9 1/2"
2	2			9	95010005-9	NUT, 5/8-11UNC, HEX, ZINC CHROMATE, SAE GR.2
2	2			8	95010005-8	WASHER, 1 3/4"OD X 11/16"ID X 9/64", ZINC PLATED
	1			7	95010005-7	BAR 1"ø X 1'-4"
	X			6	95010005-6	LEVER ROD ASSEMBLY
		4	4	5	95010005-5	BAR 1/2"ø X 0'-7"
		1	1	4	95010005-4	BAR 2" X 3/4" X 0'-5 1/2"
		1	1	3	95010005-3	BAR 2 1/2" X 3/4" X 4'-11 3/8"
		X		2	95010005-2	LEVER
			X	1	95010005-1	LEVER

APPENDIX C

Concept Materials Lists and Weights Reports

C.1 SHORTER PIN CONNECTION SYSTEM CONCEPT

```
                    A       SSSSS       A      DDDDD      SSSSS
                  A A     S     S     A A      D   D    S     S
                A   A    S           A   A     D    D   S
              AAAAAAA    SSSSS    AAAAAAA    D    D    SSSSS
             A     A         S   A     A    D    D         S
            A     A   S     S   A     A    D   D    S     S
           A     A    SSSSS    A     A   DDDDD      SSSSS

              Advanced Structures Analysis and Design System
              =        =          =            =      =


                          I.D.E.A.S.   ASADS
                             VERSION: V2.0
                         (   JULY 31, 1995    )

          LICENSED TO: I.D.E.A.S., Inc.                        SER: IDEA-001
          RUN DATE/TIME: 25-Jan-1996  16:51:18
           _
          | |
          |I|nternational          300 MONTGOMERY STREET
          |D|esign,                SUITE 789B
          |E|ngineering and        SAN FRANCISCO, CA  94104
          |A|nalysis
          |S|ervices, Inc.         TELEPHONE: (415) 362-7997
          |_|                      TELEFAX:   (415) 362-7994

==================================================================================================================================
=                                                                                                                                =
=                                         A S A D S    D E F A U L T   V A L U E S                                               =
=                                                                                                                                =
=                                  MEMBER CONSTANTS                          WATER CONSTANTS                                     =
=                                  ----------------                          ---------------                                     =
=   UNITS: LENGTH = INCHES         WEIGHT DENSITY      = 0.2836   LB/IN**3   MASS DENSITY        = 9.60 E-5 (LB-SEC**2)/IN**4   =
=          FORCE  = POUNDS         ELASTIC MODULUS     = 2.900 E7 LB/IN**2   KINEMATIC VISCOSITY = 2.03 E-3 IN**2/SEC           =
=          TIME   = SECONDS        SHEAR MODULUS       = 1.115 E7 LB/IN**2   TEMPERATURE         = 50.0     DEGREES FAHR        =
=          ANGLE  = RADIANS        COEF. OF THER. EXP. = 6.50 E-6 1/DEG-F                                                       =
=          TEMP   = DEG FAHR       BETA ANGLE          = 0.0      RADIANS    MAX NO. OF JOINTS   =  150 LOAD CASES    =   100   =
=                                  POISSON'S RATIO     = 0.30                MAX NO. OF MEMBERS  =  450 MEM SEG PROPS =  2250   =
=                                  MATERIAL            = STEEL A36           MAX NO. OF EIGVALS  =    1 SOIL STRATA   =     3   =
=                                                                            MAX NO. OF SUBSTRUC =   10 BOUND NODES   =    50   =
==================================================================================================================================

          INFILE  REV4MTO
         RESTORE 'REV4STIF'
           ***TIME TO PROCESS SAVEFILE REV4STIF.SAV OF 22-Dec-1995 16:19:39      3.90 SEC.
```

```
**************************************
*  PRINT OUTPUT FROM ASADS DATABASE  *
*  UNITS: INCH  KIP  SEC  DEG DEGF   *
**************************************

     **************************************************
     *  SPECIFIED UNITS: INCH  KIP  SEC  DEG DEGF     *
     **************************************************


 UNITS LBS INCH
     ***Units Reset To:  INCH   LB  SEC  DEG DEGF

 CONSTANTS
     **************************************************
     *  SPECIFIED UNITS: INCH   LB  SEC  DEG DEGF     *
     **************************************************

 ALL  FY  50000.


 INACTIVE MEM ALL
     ***  122 Member  Identifiers     Processed.
 ACTIVE MEM -
    1101 1105 1201 1205 1305 1306 -
    2101 2105 2201 2205           -
    3101      3201                3303 TO 3308 3312 TO 3314 -
    5101 5105 5201 5205           5303 TO 5314 -
    1016 1026 2016 2026 3016 3026
     ***   43 Member  Identifiers     Processed.
 GENERATE ITEM
     ***   43 Item    Identifiers     Generated.
 ESTABLISH ITEM GROUP 'TS3X2' IDE ALL
     ***   ITEM GROUP Group   1 Processed For  43 IDs.


 INACTIVE MEM ALL
     ***  122 Member  Identifiers     Processed.
 INACTIVE ITEMS ALL
     ***   43 Item    Identifiers     Processed.
 ACTIVE MEM -
    1013 1014 1023 1024 -
    2013 2014 2023 2024 -
    3013 3014 3023 3024 -
    4013 4014 4023 4024
     ***   16 Member  Identifiers     Processed.
 GENERATE ITEM
     ***   16 Item    Identifiers     Generated.
 ESTABLISH ITEM GROUP 'TS4X2' IDE ALL
     ***   ITEM GROUP Group   2 Processed For  16 IDs.


 INACTIVE MEM ALL
     ***  122 Member  Identifiers     Processed.
```

```
 INACTIVE ITEMS ALL
     ***   59 Item    Identifiers     Processed.
 ACTIVE MEM -
    3309 TO 3311
     ***    3 Member  Identifiers     Processed.
 GENERATE ITEM
     ***    3 Item    Identifiers     Generated.
 ESTABLISH ITEM GROUP 'TS4X3' IDE ALL
     ***   ITEM GROUP Group   3 Processed For   3 IDs.


 INACTIVE MEM ALL
     ***  122 Member  Identifiers     Processed.
 INACTIVE ITEMS ALL
     ***   62 Item    Identifiers     Processed.
 ACTIVE MEM -
    2102 TO 2104 2202 TO 2204 -
    4102 TO 4104 4202 TO 4204
     ***   12 Member  Identifiers     Processed.
 GENERATE ITEM
     ***   12 Item    Identifiers     Generated.
 ESTABLISH ITEM GROUP 'TS5X2' IDE ALL
     ***   ITEM GROUP Group   4 Processed For  12 IDs.


 INACTIVE MEM ALL
     ***  122 Member  Identifiers     Processed.
 INACTIVE ITEMS ALL
     ***   74 Item    Identifiers     Processed.
 ACTIVE MEM -
    1102 TO 1104 1202 TO 1204 -
    5102 TO 5104 5202 TO 5204 -
    1015 1025 2015 2025 3015 3025 4015 4025
     ***   20 Member  Identifiers     Processed.
 GENERATE ITEM
     ***   20 Item    Identifiers     Generated.
 ESTABLISH ITEM GROUP 'TS6X2' IDE ALL
     ***   ITEM GROUP Group   5 Processed For  20 IDs.


 INACTIVE MEM ALL
     ***  122 Member  Identifiers     Processed.
 INACTIVE ITEMS ALL
     ***   94 Item    Identifiers     Processed.
 ACTIVE MEM -
    1302 2302 3302 5302 -
    1012 1022 2012 2022 3012 3022 4012 4022
     ***   12 Member  Identifiers     Processed.
 GENERATE ITEM
     ***   12 Item    Identifiers     Generated.
 ESTABLISH ITEM GROUP 'TS6X4' IDE ALL
     ***   ITEM GROUP Group   6 Processed For  12 IDs.


 INACTIVE MEM ALL
```

```
    ***  122 Member  Identifiers     Processed.
 INACTIVE ITEMS ALL
    ***  106 Item    Identifiers     Processed.
 ACTIVE MEM -
   3102 3103 3202 3203 -
   5401 TO 5404
    ***    8 Member  Identifiers     Processed.
 GENERATE ITEM
    ***    8 Item    Identifiers     Generated.
 ESTABLISH ITEM GROUP 'L4X3' IDE ALL
    ***   ITEM GROUP Group   7 Processed For   8 IDs.


 $ NON-MODELED ITEMS
 INACTIVE ITEMS ALL
    ***  114 Item    Identifiers     Processed.
 DEFINE ITEM 'BAR---03'  WEI  31.569  X 80.0000  Y  36.000  Z  0.000  -
       TITLE 'BAR  2.500 95010005-3 ' MAT 'A36'
 DEFINE ITEM 'BAR---04'  WEI   2.339  X 80.0000  Y  36.000  Z  0.000  -
       TITLE 'BAR  2.000 95010005-4 ' MAT 'A36'
 DEFINE ITEM 'BAR4--05'  WEI   1.559  X 80.0000  Y  36.000  Z  0.000  -
       TITLE 'BAR  0.500 95010005-5 ' MAT 'A36'
 DEFINE ITEM 'BAR---07'  WEI   3.563  X 80.0000  Y  36.000  Z  0.000  -
       TITLE 'BAR  1.000 95010005-7 ' MAT 'A36'
 DEFINE ITEM 'WASH2-08'  WEI   0.100  X 80.0000  Y  36.000  Z  0.000  -
       TITLE 'WASH 1.75  95010005-8 ' MAT 'ZINCPL'
 DEFINE ITEM 'NUTS2-09'  WEI   0.200  X 80.0000  Y  36.000  Z  0.000  -
       TITLE 'NUTS HEX   95010005-9 ' MAT 'SAEGR2'
 DEFINE ITEM 'LVRSHF10'  WEI   4.788  X 80.0000  Y  36.000  Z  0.000  -
       TITLE 'LEVER 1.00 95010005-10' MAT 'A36'
 ESTABLISH ITEM GROUP 'ASS-LEVR' IDE ALL
    ***   ITEM GROUP Group   8 Processed For   7 IDs.


 INACTIVE ITEMS ALL
    ***  121 Item    Identifiers     Processed.
 DEFINE ITEM 'WAS28-08'  WEI   2.800  X 45.0000  Y  36.000  Z  0.000  -
       TITLE 'WASH  1.75 95010005-8 ' MAT 'ZINCPL'
 DEFINE ITEM 'NUT28-09'  WEI   5.600  X 45.0000  Y  36.000  Z  0.000  -
       TITLE 'NUT HEX    95010005-9 ' MAT 'SAEGR2'
 DEFINE ITEM 'KRL14-12'  WEI  14.000  X 45.0000  Y  36.000  Z  0.000  -
       TITLE 'ROLLER 8IN 95010005-12' MAT 'RUBBER'
 DEFINE ITEM 'BAR14-13'  WEI  13.397  X 45.0000  Y  36.000  Z  0.000  -
       TITLE 'BAR  0.625 95010005-13' MAT 'A36'
 ESTABLISH ITEM GROUP 'ASS-ROLL' IDE ALL
    ***   ITEM GROUP Group   9 Processed For   4 IDs.


 INACTIVE ITEMS ALL
    ***  125 Item    Identifiers     Processed.
 DEFINE ITEM 'BAR---13'  WEI  10.000  X 80.0000  Y  24.000  Z  0.000 -
       TITLE 'BAR  4.00  95010002-13' MAT 'FY50'
 DEFINE ITEM 'CASING15'  WEI  35.343  X  3.8125  Y  60.000  Z  0.000 -
       TITLE 'TUBE 14.25 95010002-15' MAT 'FY50'
```

```
 DEFINE ITEM 'CASING16'  WEI  41.137  X  6.4375  Y  12.000  Z  0.000 -
        TITLE 'TUBE 14.00 95010002-16' MAT 'FY50'
 DEFINE ITEM 'STIFF-18'  WEI  24.0    X  3.4375  Y  60.000  Z  0.000 -
        TITLE 'STF  0.500 95010002-18' MAT 'FY50'
 DEFINE ITEM 'STIFF-19'  WEI  24.0    X  3.4375  Y  60.000  Z  0.000 -
        TITLE 'STF  0.500 95010002-19' MAT 'FY50'
 DEFINE ITEM 'STIFF-20'  WEI  20.0    X  3.4375  Y  12.000  Z  0.000 -
        TITLE 'STF  0.500 95010002-20' MAT 'FY50'
 DEFINE ITEM 'STIFF-21'  WEI  20.0    X  3.4375  Y  12.000  Z  0.000 -
        TITLE 'STF  0.500 95010002-21' MAT 'FY50'
 DEFINE ITEM 'ENDPL-22'  WEI 180.7    X  0.000   Y  48.000  Z  0.000 -
        TITLE 'PLT  0.625 95010002-22' MAT 'FY50'
 DEFINE ITEM 'PLATE-23'  WEI  16.0    X  8.875   Y  60.000  Z  0.000 -
        TITLE 'PLT  0.500 95010002-23' MAT 'FY50'
 DEFINE ITEM 'PLATE-24'  WEI  18.0    X  8.875   Y  12.000  Z  0.000 -
        TITLE 'PLT  0.500 95010002-24' MAT 'FY50'
 DEFINE ITEM 'FUNPL-25'  WEI  88.9    X  0.000   Y  48.000  Z  0.000 -
        TITLE 'FUNNEL 0.5 95010002-25' MAT 'FY50'
 DEFINE ITEM 'RING--28'  WEI  10.0    X  8.875   Y  60.000  Z  0.000 -
        TITLE 'RING       95010002-28' MAT 'FY50'
 DEFINE ITEM 'PLATE-XX'  WEI  81.6    X 12.000   Y  36.000  Z  0.000 -
        TITLE 'PLATE 0.500 THK       ' MAT 'FY50'
 DEFINE ITEM 'GUILLPLT'  WEI 132.0    X 12.000   Y  12.000  Z  0.000 -
        TITLE 'GUILLOTINE 2.25 THK   ' MAT 'FY50'
 DEFINE ITEM 'GUILLPLT'  WEI 132.0    X 12.000   Y  60.000  Z  0.000 -
        TITLE 'GUILLOTINE 2.25 THK   ' MAT 'FY50'
 ESTABLISH ITEM GROUP 'ASS-MISC' IDE ALL
     ***   ITEM GROUP Group  10 Processed For  15 IDs.


 ACTIVE ITEMS ALL
     ***  140 Item    Identifiers     Processed.
 ESTABLISH ITEM GROUP 'ASSEMBLY' GROUPS -
    'TS3X2'  'TS4X2' 'TS4X3' 'TS5X2' 'TS6X2' 'TS6X4' 'L4X3' -
    'ASS-LEVR'  'ASS-ROLL'  'ASS-MISC'
     ***   ITEM GROUP Group  11 Processed For 140 IDs.



 INACTIVE ITEMS ALL
     ***  140 Item    Identifiers     Processed.
 DEFINE ITEM 'TUBE--03'  WEI 105.286  X  0.0000  Y  60.000  Z  0.000 -
        TITLE 'TUBE 15.75 95010004-3 ' MAT 'FY50'
 DEFINE ITEM 'BAR---04'  WEI  28.000  X  0.0000  Y  60.000  Z  0.000 -
        TITLE 'BAR  13.00 95010004-4 ' MAT 'FY50'
 DEFINE ITEM 'BAR---05'  WEI  55.000  X  0.0000  Y  60.000  Z  0.000 -
        TITLE 'BAR  15.75 95010004-5 ' MAT 'FY50'
 DEFINE ITEM 'TUBE--06'  WEI  19.000  X  0.0000  Y  60.000  Z  0.000 -
        TITLE 'TUBE 15.75 95010004-6 ' MAT 'FY50'
 DEFINE ITEM 'BAR---07'  WEI   0.750  X  0.0000  Y  60.000  Z  0.000 -
        TITLE 'BAR   0.75 95010004-7 ' MAT 'FY50'
 ESTABLISH ITEM GROUP 'PIN-CASE' IDE ALL
     ***   ITEM GROUP Group  12 Processed For   5 IDs.
```

```
 INACTIVE ITEMS ALL
     ***  145 Item    Identifiers     Processed.
 DEFINE ITEM 'TUBE--09'  WEI  29.310  X  0.0000  Y  60.000  Z  0.000 -
        TITLE 'TUBE 15.00 95010004-9 ' MAT 'FY50'
 DEFINE ITEM 'PIPE--10'  WEI 113.750  X  0.0000  Y  60.000  Z  0.000 -
        TITLE 'PIPE 12.00 95010004-10' MAT 'FY50'
 DEFINE ITEM 'TUBE--11'  WEI  77.000  X  0.0000  Y  60.000  Z  0.000 -
        TITLE 'TUBE 12.75 95010004-11' MAT 'FY50'
 DEFINE ITEM 'TUBE--12'  WEI  27.000  X  0.0000  Y  60.000  Z  0.000 -
        TITLE 'TUBE 12.75 95010004-12' MAT 'FY50'
 DEFINE ITEM 'BAR---13'  WEI 247.980  X  0.0000  Y  60.000  Z  0.000 -
        TITLE 'BAR  12.75 95010004-13' MAT 'FY50'
 DEFINE ITEM 'PLT---14'  WEI  11.400  X  0.0000  Y  60.000  Z  0.000 -
        TITLE 'BAR  11.75 95010004-14' MAT 'FY50'
 $ DEFINE ITEM 'BRGPLTS '  WEI  19.300  X  0.0000  Y  60.000  Z  0.000 -
 ESTABLISH ITEM GROUP 'PIN-NOSE' IDE ALL
     ***   ITEM GROUP Group  13 Processed For   6 IDs.


 INACTIVE ITEMS ALL
     ***  151 Item    Identifiers     Processed.
 DEFINE ITEM 'PINCAP15'  WEI  30.000  X  0.0000  Y  60.000  Z  0.000 -
        TITLE 'CAP  12.75 95010004-15' MAT 'PVC'
 DEFINE ITEM 'PINROD19'  WEI  16.258  X  0.0000  Y  60.000  Z  0.000 -
        TITLE 'ROD        95010004-19' MAT 'FY50'
 DEFINE ITEM 'PINNUT20'  WEI   0.500  X  0.0000  Y  60.000  Z  0.000 -
        TITLE 'NUT HEX    95010004-20' MAT 'SAEGR2'
 DEFINE ITEM 'SPRING21'  WEI 187.700  X  0.0000  Y  60.000  Z  0.000 -
        TITLE 'SPRING     95010004-21' MAT 'FY50'
 DEFINE ITEM 'PINPLT22'  WEI   3.987  X  0.0000  Y  60.000  Z  0.000 -
        TITLE 'PIN PLATE  95010004-22' MAT 'FY50'
 ESTABLISH ITEM GROUP 'PIN-MISC' IDE ALL
     ***   ITEM GROUP Group  14 Processed For   5 IDs.


 ACTIVE ITEMS ALL
     ***  156 Item    Identifiers     Processed.
 ESTABLISH ITEM GROUP 'STAB-PIN' GROUPS -
    'PIN-CASE' 'PIN-NOSE' 'PIN-MISC'
     ***   ITEM GROUP Group  15 Processed For  16 IDs.


 $ BARGE SUPPORT STRUCTURE
 INACTIVE ITEMS ALL
     ***  156 Item    Identifiers     Processed.
 DEFINE ITEM 'BHDPLT  '  WEI 1183.200  X  0.0000  Y  36.000  Z  0.000 -
        TITLE 'BHD PLT 0.25 THK      ' MAT 'FY50'
 DEFINE ITEM 'BHD-L4X3'  WEI  767.700  X  0.0000  Y  36.000  Z  0.000 -
        TITLE 'BHD STF L4X3X3/8      ' MAT 'FY50'
 DEFINE ITEM 'CRNR-PLT'  WEI   61.200  X  0.0000  Y  36.000  Z  0.000 -
        TITLE 'STIFF 0.50 THK        ' MAT 'FY50'
 ESTABLISH ITEM GROUP 'ENC-BHDS' IDE ALL
     ***   ITEM GROUP Group  16 Processed For   3 IDs.
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 INACTIVE ITEMS ALL
     ***  159 Item    Identifiers     Processed.
 DEFINE ITEM 'TS6X4BOT'  WEI  142.150  X  0.0000  Y  36.000  Z  0.000 -
        TITLE 'TS6X4X.500            ' MAT 'FY50'
 DEFINE ITEM 'TS6X4TOP'  WEI  104.243  X  0.0000  Y  36.000  Z  0.000 -
        TITLE 'TS6X4X.500            ' MAT 'FY50'
 DEFINE ITEM 'TS6X2TOP'  WEI   63.323  X  0.0000  Y  36.000  Z  0.000 -
        TITLE 'TS6X2X.375            ' MAT 'FY50'
 DEFINE ITEM 'TS6X4SID'  WEI  454.880  X  0.0000  Y  36.000  Z  0.000 -
        TITLE 'TS6X4X.500            ' MAT 'FY50'
 DEFINE ITEM 'TS6X2SID'  WEI  276.320  X  0.0000  Y  36.000  Z  0.000 -
        TITLE 'TS6X2X.375            ' MAT 'FY50'
 DEFINE ITEM 'PADEYES8'  WEI   60.000  X  0.0000  Y  36.000  Z  0.000 -
        TITLE 'PADEYE                ' MAT 'FY50'
 DEFINE ITEM 'PIN/NUT4'  WEI   20.000  X  0.0000  Y  36.000  Z  0.000 -
        TITLE 'PIN&NUT               ' MAT 'FY50'
 ESTABLISH ITEM GROUP 'ENC--BMS' IDE ALL
     ***   ITEM GROUP Group  17 Processed For   7 IDs.


 INACTIVE ITEMS ALL
     ***  166 Item    Identifiers     Processed.
 DEFINE ITEM 'STFPLT24'  WEI   50.000  X  0.0000  Y  36.000  Z  0.000 -
        TITLE 'STF PLT 0.500 THK     ' MAT 'FY50'
 DEFINE ITEM 'BRGPLT-8'  WEI   50.000  X  0.0000  Y  36.000  Z  0.000 -
        TITLE 'BRG PLT 0.250 THK     ' MAT 'FY50'
 DEFINE ITEM 'SHIMPLTS'  WEI   30.000  X  0.0000  Y  36.000  Z  0.000 -
        TITLE 'SHIMS VARY THK        ' MAT 'FY50'
 ESTABLISH ITEM GROUP 'ENC-CONN' IDE ALL
     ***   ITEM GROUP Group  18 Processed For   3 IDs.


 ACTIVE ITEMS ALL
     ***  169 Item    Identifiers     Processed.
 ESTABLISH ITEM GROUP 'ENC-SPPT' GROUPS -
    'ENC-BHDS' 'ENC--BMS' 'ENC-CONN'
     ***   ITEM GROUP Group  19 Processed For  13 IDs.


 ACTIVE ITEMS ALL
     ***  169 Item    Identifiers     Processed.
 ESTABLISH ITEM GROUP 'SHORTPIN' GROUPS -
    'ASSEMBLY'  'STAB-PIN'  'ENC-SPPT'
     ***   ITEM GROUP Group  20 Processed For 169 IDs.


 ESTABLISH ITEM GROUP 'FY50'   MATERIAL 'FY50'
     ***              Group  21 Processed For 156 IDs.

 ESTABLISH ITEM GROUP 'A36'    MATERIAL 'A36'
     ***              Group  22 Processed For   6 IDs.

 ESTABLISH ITEM GROUP 'SAEGR2' MATERIAL 'SAEGR2'
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    ***              Group  23 Processed For   3 IDs.

 ESTABLISH ITEM GROUP 'ZINCPL' MATERIAL 'ZINCPL'
    ***              Group  24 Processed For   2 IDs.

 ESTABLISH ITEM GROUP 'RUBBER' MATERIAL 'RUBBER'
    ***              Group  25 Processed For   1 IDs.

 ESTABLISH ITEM GROUP 'PVC'    MATERIAL 'PVC'
    ***              Group  26 Processed For   1 IDs.

 ESTABLISH ITEM GROUP 'MATERIAL' GROUP -
   'FY50' 'A36' 'SAEGR2' 'ZINCPL' 'RUBBER' 'PVC'
    ***   ITEM GROUP Group  27 Processed For 169 IDs.


 UNITS LBS FEET
    ***Units Reset To:  FEET   LB  SEC  DEG DEGF

 ACTIVE ITEMS ALL
    ***  169 Item    Identifiers     Processed.
 PRINT MTO LEV 4 GROUP 'SHORTPIN'
```

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*************************************
*  PRINT OUTPUT FROM ASADS DATABASE  *
*  UNITS: FEET   LB  SEC  DEG DEGF   *
*************************************
```

WEIGHT REPORT:
LEVEL 5, 1 GROUPS

WTO LEVEL 0 GROUPS: 1

WTO LEVEL 1 GROUPS: 1

GROUP NO.	GROUP ID	GROUP TITLE	GROUP WEIGHT	GROUP LENGTH	GROUP MATL	COG X	COG Y	COG Z
20	'SHORTPIN'		6.835E+03	1.369E+02		7.666E-01	3.396E+00	0.000E+00
TOTAL			6.835E+03	1.369E+02		7.666E-01	3.396E+00	0.000E+00

169 Items Processed.

WTO LEVEL 2 GROUPS: 1

GROUP: 20 'SHORTPIN'

GROUP NO.	GROUP ID	GROUP TITLE	GROUP WEIGHT	GROUP LENGTH	GROUP MATL	COG X	COG Y	COG Z
11	'ASSEMBLY'		2.619E+03	1.369E+02		2.001E+00	3.306E+00	0.000E+00
15	'STAB-PIN'		9.529E+02			0.000E+00	5.000E+00	0.000E+00
19	'ENC-SPPT'		3.263E+03			0.000E+00	3.000E+00	0.000E+00
TOTAL			6.835E+03	1.369E+02		7.666E-01	3.396E+00	0.000E+00

169 Items Processed.

WTO LEVEL 3 GROUPS: 3

GROUP: 11 'ASSEMBLY'

GROUP NO.	GROUP ID	GROUP TITLE	GROUP WEIGHT	GROUP LENGTH	GROUP MATL	COG X	COG Y	COG Z
1	'TS3X2'		3.159E+02	4.442E+01		4.283E+00	3.301E+00	0.000E+00
2	'TS4X2'		1.983E+02	2.250E+01		2.292E+00	3.062E+00	0.000E+00
3	'TS4X3'		2.327E+01	1.833E+00		3.833E+00	4.125E+00	0.000E+00
4	'TS5X2'		1.438E+02	1.133E+01		2.331E+00	3.375E+00	0.000E+00
5	'TS6X2'		3.904E+02	2.258E+01		3.079E+00	3.062E+00	0.000E+00
6	'TS6X4'		4.907E+02	1.725E+01		7.500E-01	3.041E+00	0.000E+00
7	'L4X3'		1.435E+02	1.700E+01		3.533E+00	5.017E+00	0.000E+00
8	'ASS-LEVR'		4.412E+01			6.667E+00	3.000E+00	0.000E+00
9	'ASS-ROLL'		3.580E+01			3.750E+00	3.000E+00	0.000E+00
10	'ASS-MISC'		8.337E+02			6.037E-01	3.336E+00	0.000E+00

TOTAL			2.619E+03	1.369E+02		2.001E+00	3.306E+00	0.000E+00

140 Items Processed.

GROUP: 15 'STAB-PIN'

GROUP NO.	GROUP ID	GROUP TITLE	GROUP WEIGHT	GROUP LENGTH	GROUP MATL	COG X	COG Y	COG Z
12	'PIN-CASE'		2.080E+02			0.000E+00	5.000E+00	0.000E+00
13	'PIN-NOSE'		5.064E+02			0.000E+00	5.000E+00	0.000E+00
14	'PIN-MISC'		2.384E+02			0.000E+00	5.000E+00	0.000E+00
TOTAL			9.529E+02			0.000E+00	5.000E+00	0.000E+00

16 Items Processed.

GROUP: 19 'ENC-SPPT'

GROUP NO.	GROUP ID	GROUP TITLE	GROUP WEIGHT	GROUP LENGTH	GROUP MATL	COG X	COG Y	COG Z
16	'ENC-BHDS'		2.012E+03			0.000E+00	3.000E+00	0.000E+00
17	'ENC--BMS'		1.121E+03			0.000E+00	3.000E+00	0.000E+00
18	'ENC-CONN'		1.300E+02			0.000E+00	3.000E+00	0.000E+00
TOTAL			3.263E+03			0.000E+00	3.000E+00	0.000E+00

13 Items Processed.

WTO LEVEL 4 GROUPS: 16

GROUP: 1 'TS3X2'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
1	'M1101S1'	TS3X2X.250	4.149E+00	5.833E-01	'FY50'	3.750E-01	2.500E-01	9.167E-01
2	'M1105S1'	TS3X2X.250	1.422E+01	2.000E+00	'FY50'	4.875E+00	2.500E-01	9.167E-01
3	'M1201S1'	TS3X2X.250	4.149E+00	5.833E-01	'FY50'	3.750E-01	2.500E-01	-9.167E-01
4	'M1205S1'	TS3X2X.250	1.422E+01	2.000E+00	'FY50'	4.875E+00	2.500E-01	-9.167E-01
5	'M1305S1'	TS3X2X.250	1.304E+01	1.833E+00	'FY50'	3.833E+00	2.500E-01	0.000E+00
6	'M1306S1'	TS3X2X.250	1.304E+01	1.833E+00	'FY50'	5.917E+00	2.500E-01	0.000E+00
7	'M2101S1'	TS3X2X.250	4.149E+00	5.833E-01	'FY50'	3.750E-01	1.750E+00	9.167E-01
8	'M2105S1'	TS3X2X.250	1.422E+01	2.000E+00	'FY50'	4.875E+00	1.750E+00	9.167E-01
9	'M2201S1'	TS3X2X.250	4.149E+00	5.833E-01	'FY50'	3.750E-01	1.750E+00	-9.167E-01
10	'M2205S1'	TS3X2X.250	1.422E+01	2.000E+00	'FY50'	4.875E+00	1.750E+00	-9.167E-01
11	'M3101S1'	TS3X2X.250	4.149E+00	5.833E-01	'FY50'	3.750E-01	4.125E+00	9.167E-01
12	'M3201S1'	TS3X2X.250	4.149E+00	5.833E-01	'FY50'	3.750E-01	4.125E+00	-9.167E-01
13	'M3303S1'	TS3X2X.250	3.852E+00	5.417E-01	'FY50'	1.167E+00	4.125E+00	6.458E-01
14	'M3304S1'	TS3X2X.250	5.334E+00	7.500E-01	'FY50'	1.167E+00	4.125E+00	0.000E+00
15	'M3305S1'	TS3X2X.250	3.852E+00	5.417E-01	'FY50'	1.167E+00	4.125E+00	-6.458E-01
16	'M3306S1'	TS3X2X.250	3.852E+00	5.417E-01	'FY50'	3.417E+00	4.125E+00	6.458E-01
17	'M3307S1'	TS3X2X.250	5.334E+00	7.500E-01	'FY50'	3.417E+00	4.125E+00	0.000E+00
18	'M3308S1'	TS3X2X.250	3.852E+00	5.417E-01	'FY50'	3.417E+00	4.125E+00	-6.458E-01

19	'M3312S1'	TS3X2X.250	3.852E+00	5.417E-01	'FY50'	5.917E+00	4.125E+00	6.458E-01
20	'M3313S1'	TS3X2X.250	5.334E+00	7.500E-01	'FY50'	5.917E+00	4.125E+00	0.000E+00
21	'M3314S1'	TS3X2X.250	3.852E+00	5.417E-01	'FY50'	5.917E+00	4.125E+00	-6.458E-01
22	'M5101S1'	TS3X2X.250	4.149E+00	5.833E-01	'FY50'	3.750E-01	5.875E+00	9.167E-01
23	'M5105S1'	TS3X2X.250	1.422E+01	2.000E+00	'FY50'	4.875E+00	5.875E+00	9.167E-01
24	'M5201S1'	TS3X2X.250	4.149E+00	5.833E-01	'FY50'	3.750E-01	5.875E+00	-9.167E-01
25	'M5205S1'	TS3X2X.250	1.422E+01	2.000E+00	'FY50'	4.875E+00	5.875E+00	-9.167E-01
26	'M5303S1'	TS3X2X.250	3.852E+00	5.417E-01	'FY50'	1.167E+00	5.875E+00	6.458E-01
27	'M5304S1'	TS3X2X.250	5.334E+00	7.500E-01	'FY50'	1.167E+00	5.875E+00	0.000E+00
28	'M5305S1'	TS3X2X.250	3.852E+00	5.417E-01	'FY50'	1.167E+00	5.875E+00	-6.458E-01
29	'M5306S1'	TS3X2X.250	3.852E+00	5.417E-01	'FY50'	3.417E+00	5.875E+00	6.458E-01
30	'M5307S1'	TS3X2X.250	5.334E+00	7.500E-01	'FY50'	3.417E+00	5.875E+00	0.000E+00
31	'M5308S1'	TS3X2X.250	3.852E+00	5.417E-01	'FY50'	3.417E+00	5.875E+00	-6.458E-01
32	'M5309S1'	TS3X2X.250	3.852E+00	5.417E-01	'FY50'	3.833E+00	5.875E+00	6.458E-01
33	'M5310S1'	TS3X2X.250	5.334E+00	7.500E-01	'FY50'	3.833E+00	5.875E+00	0.000E+00
34	'M5311S1'	TS3X2X.250	3.852E+00	5.417E-01	'FY50'	3.833E+00	5.875E+00	-6.458E-01
35	'M5312S1'	TS3X2X.250	3.852E+00	5.417E-01	'FY50'	5.917E+00	5.875E+00	6.458E-01
36	'M5313S1'	TS3X2X.250	5.334E+00	7.500E-01	'FY50'	5.917E+00	5.875E+00	0.000E+00
37	'M5314S1'	TS3X2X.250	3.852E+00	5.417E-01	'FY50'	5.917E+00	5.875E+00	-6.458E-01
38	'M1016S1'	TS3X2X.250	1.067E+01	1.500E+00	'FY50'	5.917E+00	1.000E+00	9.167E-01
39	'M1026S1'	TS3X2X.250	1.067E+01	1.500E+00	'FY50'	5.917E+00	1.000E+00	-9.167E-01
40	'M2016S1'	TS3X2X.250	1.689E+01	2.375E+00	'FY50'	5.917E+00	2.938E+00	9.167E-01
41	'M2026S1'	TS3X2X.250	1.689E+01	2.375E+00	'FY50'	5.917E+00	2.938E+00	-9.167E-01
42	'M3016S1'	TS3X2X.250	1.245E+01	1.750E+00	'FY50'	5.917E+00	5.000E+00	9.167E-01
43	'M3026S1'	TS3X2X.250	1.245E+01	1.750E+00	'FY50'	5.917E+00	5.000E+00	-9.167E-01
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TOTAL			3.159E+02	4.442E+01		4.283E+00	3.301E+00	0.000E+00

43 Items Processed.

GROUP: 2 'TS4X2'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
44	'M1013S1'	TS4X2X.250	1.322E+01	1.500E+00	'FY50'	1.167E+00	1.000E+00	9.167E-01
45	'M1014S1'	TS4X2X.250	1.322E+01	1.500E+00	'FY50'	3.417E+00	1.000E+00	9.167E-01
46	'M1023S1'	TS4X2X.250	1.322E+01	1.500E+00	'FY50'	1.167E+00	1.000E+00	-9.167E-01
47	'M1024S1'	TS4X2X.250	1.322E+01	1.500E+00	'FY50'	3.417E+00	1.000E+00	-9.167E-01
48	'M2013S1'	TS4X2X.250	2.093E+01	2.375E+00	'FY50'	1.167E+00	2.938E+00	9.167E-01
49	'M2014S1'	TS4X2X.250	2.093E+01	2.375E+00	'FY50'	3.417E+00	2.938E+00	9.167E-01
50	'M2023S1'	TS4X2X.250	2.093E+01	2.375E+00	'FY50'	1.167E+00	2.938E+00	-9.167E-01
51	'M2024S1'	TS4X2X.250	2.093E+01	2.375E+00	'FY50'	3.417E+00	2.938E+00	-9.167E-01
52	'M3013S1'	TS4X2X.250	7.712E+00	8.750E-01	'FY50'	1.167E+00	4.563E+00	9.167E-01
53	'M3014S1'	TS4X2X.250	7.712E+00	8.750E-01	'FY50'	3.417E+00	4.563E+00	9.167E-01
54	'M3023S1'	TS4X2X.250	7.712E+00	8.750E-01	'FY50'	1.167E+00	4.563E+00	-9.167E-01
55	'M3024S1'	TS4X2X.250	7.712E+00	8.750E-01	'FY50'	3.417E+00	4.563E+00	-9.167E-01
56	'M4013S1'	TS4X2X.250	7.712E+00	8.750E-01	'FY50'	1.167E+00	5.438E+00	9.167E-01
57	'M4014S1'	TS4X2X.250	7.712E+00	8.750E-01	'FY50'	3.417E+00	5.438E+00	9.167E-01
58	'M4023S1'	TS4X2X.250	7.712E+00	8.750E-01	'FY50'	1.167E+00	5.438E+00	-9.167E-01
59	'M4024S1'	TS4X2X.250	7.712E+00	8.750E-01	'FY50'	3.417E+00	5.438E+00	-9.167E-01
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TOTAL			1.983E+02	2.250E+01		2.292E+00	3.062E+00	0.000E+00

16 Items Processed.

GROUP: 3 'TS4X3'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
60	'M3309S1'	TS4X3X.3125	6.875E+00	5.417E-01	'FY50'	3.833E+00	4.125E+00	6.458E-01
61	'M3310S1'	TS4X3X.3125	9.519E+00	7.500E-01	'FY50'	3.833E+00	4.125E+00	0.000E+00
62	'M3311S1'	TS4X3X.3125	6.875E+00	5.417E-01	'FY50'	3.833E+00	4.125E+00	-6.458E-01
TOTAL			2.327E+01	1.833E+00		3.833E+00	4.125E+00	0.000E+00

3 Items Processed.

GROUP: 4 'TS5X2'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
63	'M2102S1'	TS5X2X.3125	3.173E+00	2.500E-01	'FY50'	9.583E-01	1.750E+00	9.167E-01
64	'M2103S1'	TS5X2X.3125	2.856E+01	2.250E+00	'FY50'	2.292E+00	1.750E+00	9.167E-01
65	'M2104S1'	TS5X2X.3125	4.231E+00	3.333E-01	'FY50'	3.625E+00	1.750E+00	9.167E-01
66	'M2202S1'	TS5X2X.3125	3.173E+00	2.500E-01	'FY50'	9.583E-01	1.750E+00	-9.167E-01
67	'M2203S1'	TS5X2X.3125	2.856E+01	2.250E+00	'FY50'	2.292E+00	1.750E+00	-9.167E-01
68	'M2204S1'	TS5X2X.3125	4.231E+00	3.333E-01	'FY50'	3.625E+00	1.750E+00	-9.167E-01
69	'M4102S1'	TS5X2X.3125	3.173E+00	2.500E-01	'FY50'	9.583E-01	5.000E+00	9.167E-01
70	'M4103S1'	TS5X2X.3125	2.856E+01	2.250E+00	'FY50'	2.292E+00	5.000E+00	9.167E-01
71	'M4104S1'	TS5X2X.3125	4.231E+00	3.333E-01	'FY50'	3.625E+00	5.000E+00	9.167E-01
72	'M4202S1'	TS5X2X.3125	3.173E+00	2.500E-01	'FY50'	9.583E-01	5.000E+00	-9.167E-01
73	'M4203S1'	TS5X2X.3125	2.856E+01	2.250E+00	'FY50'	2.292E+00	5.000E+00	-9.167E-01
74	'M4204S1'	TS5X2X.3125	4.231E+00	3.333E-01	'FY50'	3.625E+00	5.000E+00	-9.167E-01
TOTAL			1.438E+02	1.133E+01		2.331E+00	3.375E+00	0.000E+00

12 Items Processed.

GROUP: 5 'TS6X2'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
75	'M1102S1'	TS6X2X.375	4.322E+00	2.500E-01	'FY50'	9.583E-01	2.500E-01	9.167E-01
76	'M1103S1'	TS6X2X.375	3.889E+01	2.250E+00	'FY50'	2.292E+00	2.500E-01	9.167E-01
77	'M1104S1'	TS6X2X.375	5.762E+00	3.333E-01	'FY50'	3.625E+00	2.500E-01	9.167E-01
78	'M1202S1'	TS6X2X.375	4.322E+00	2.500E-01	'FY50'	9.583E-01	2.500E-01	-9.167E-01
79	'M1203S1'	TS6X2X.375	3.889E+01	2.250E+00	'FY50'	2.292E+00	2.500E-01	-9.167E-01
80	'M1204S1'	TS6X2X.375	5.762E+00	3.333E-01	'FY50'	3.625E+00	2.500E-01	-9.167E-01
81	'M5102S1'	TS6X2X.375	4.322E+00	2.500E-01	'FY50'	9.583E-01	5.875E+00	9.167E-01
82	'M5103S1'	TS6X2X.375	3.889E+01	2.250E+00	'FY50'	2.292E+00	5.875E+00	9.167E-01
83	'M5104S1'	TS6X2X.375	5.762E+00	3.333E-01	'FY50'	3.625E+00	5.875E+00	9.167E-01
84	'M5202S1'	TS6X2X.375	4.322E+00	2.500E-01	'FY50'	9.583E-01	5.875E+00	-9.167E-01
85	'M5203S1'	TS6X2X.375	3.889E+01	2.250E+00	'FY50'	2.292E+00	5.875E+00	-9.167E-01
86	'M5204S1'	TS6X2X.375	5.762E+00	3.333E-01	'FY50'	3.625E+00	5.875E+00	-9.167E-01
87	'M1015S1'	TS6X2X.375	2.593E+01	1.500E+00	'FY50'	3.833E+00	1.000E+00	9.167E-01
88	'M1025S1'	TS6X2X.375	2.593E+01	1.500E+00	'FY50'	3.833E+00	1.000E+00	-9.167E-01

89	'M2015S1'	TS6X2X.375	4.105E+01	2.375E+00	'FY50'	3.833E+00	2.938E+00	9.167E-01
90	'M2025S1'	TS6X2X.375	4.105E+01	2.375E+00	'FY50'	3.833E+00	2.938E+00	-9.167E-01
91	'M3015S1'	TS6X2X.375	1.513E+01	8.750E-01	'FY50'	3.833E+00	4.563E+00	9.167E-01
92	'M3025S1'	TS6X2X.375	1.513E+01	8.750E-01	'FY50'	3.833E+00	4.563E+00	-9.167E-01
93	'M4015S1'	TS6X2X.375	1.513E+01	8.750E-01	'FY50'	3.833E+00	5.438E+00	9.167E-01
94	'M4025S1'	TS6X2X.375	1.513E+01	8.750E-01	'FY50'	3.833E+00	5.438E+00	-9.167E-01
TOTAL			3.904E+02	2.258E+01		3.079E+00	3.062E+00	0.000E+00

20 Items Processed.

GROUP: 6 'TS6X4'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
95	'M1302S1'	TS6X4X.500	4.267E+01	1.500E+00	'FY50'	7.500E-01	2.500E-01	0.000E+00
96	'M2302S1'	TS6X4X.500	4.267E+01	1.500E+00	'FY50'	7.500E-01	1.750E+00	0.000E+00
97	'M3302S1'	TS6X4X.500	4.267E+01	1.500E+00	'FY50'	7.500E-01	4.125E+00	0.000E+00
98	'M5302S1'	TS6X4X.500	4.267E+01	1.500E+00	'FY50'	7.500E-01	5.875E+00	0.000E+00
99	'M1012S1'	TS6X4X.500	4.267E+01	1.500E+00	'FY50'	7.500E-01	1.000E+00	9.167E-01
100	'M1022S1'	TS6X4X.500	4.267E+01	1.500E+00	'FY50'	7.500E-01	1.000E+00	-9.167E-01
101	'M2012S1'	TS6X4X.500	6.756E+01	2.375E+00	'FY50'	7.500E-01	2.938E+00	9.167E-01
102	'M2022S1'	TS6X4X.500	6.756E+01	2.375E+00	'FY50'	7.500E-01	2.938E+00	-9.167E-01
103	'M3012S1'	TS6X4X.500	2.489E+01	8.750E-01	'FY50'	7.500E-01	4.563E+00	9.167E-01
104	'M3022S1'	TS6X4X.500	2.489E+01	8.750E-01	'FY50'	7.500E-01	4.563E+00	-9.167E-01
105	'M4012S1'	TS6X4X.500	2.489E+01	8.750E-01	'FY50'	7.500E-01	5.438E+00	9.167E-01
106	'M4022S1'	TS6X4X.500	2.489E+01	8.750E-01	'FY50'	7.500E-01	5.438E+00	-9.167E-01
TOTAL			4.907E+02	1.725E+01		7.500E-01	3.041E+00	0.000E+00

12 Items Processed.

GROUP: 7 'L4X3'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
107	'M3102S1'	L4X3X3/8	1.828E+01	2.167E+00	'FY50'	2.292E+00	4.125E+00	3.750E-01
108	'M3103S1'	L4X3X3/8	1.688E+01	2.000E+00	'FY50'	4.875E+00	4.125E+00	3.750E-01
109	'M3202S1'	L4X3X3/8	1.828E+01	2.167E+00	'FY50'	2.292E+00	4.125E+00	-3.750E-01
110	'M3203S1'	L4X3X3/8	1.688E+01	2.000E+00	'FY50'	4.875E+00	4.125E+00	-3.750E-01
111	'M5401S1'	L4X3X3/8	1.899E+01	2.250E+00	'FY50'	2.292E+00	5.875E+00	3.750E-01
112	'M5402S1'	L4X3X3/8	1.758E+01	2.083E+00	'FY50'	4.875E+00	5.875E+00	3.750E-01
113	'M5403S1'	L4X3X3/8	1.899E+01	2.250E+00	'FY50'	2.292E+00	5.875E+00	-3.750E-01
114	'M5404S1'	L4X3X3/8	1.758E+01	2.083E+00	'FY50'	4.875E+00	5.875E+00	-3.750E-01
TOTAL			1.435E+02	1.700E+01		3.533E+00	5.017E+00	0.000E+00

8 Items Processed.

GROUP: 8 'ASS-LEVR'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z

115	'BAR---03'	'BAR 2.500 95010005-3 '	3.157E+01		'A36'	6.667E+00	3.000E+00	0.000E+00
116	'BAR---04'	'BAR 2.000 95010005-4 '	2.339E+00		'A36'	6.667E+00	3.000E+00	0.000E+00
117	'BAR4--05'	'BAR 0.500 95010005-5 '	1.559E+00		'A36'	6.667E+00	3.000E+00	0.000E+00
118	'BAR---07'	'BAR 1.000 95010005-7 '	3.563E+00		'A36'	6.667E+00	3.000E+00	0.000E+00
119	'WASH2-08'	'WASH 1.75 95010005-8 '	1.000E-01		'ZINCPL'	6.667E+00	3.000E+00	0.000E+00
120	'NUTS2-09'	'NUTS HEX 95010005-9 '	2.000E-01		'SAEGR2'	6.667E+00	3.000E+00	0.000E+00
121	'LVRSHF10'	'LEVER 1.00 95010005-10'	4.788E+00		'A36'	6.667E+00	3.000E+00	0.000E+00
TOTAL			4.412E+01			6.667E+00	3.000E+00	0.000E+00

7 Items Processed.

GROUP: 9 'ASS-ROLL'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
122	'WAS28-08'	'WASH 1.75 95010005-8 '	2.800E+00		'ZINCPL'	3.750E+00	3.000E+00	0.000E+00
123	'NUT28-09'	'NUT HEX 95010005-9 '	5.600E+00		'SAEGR2'	3.750E+00	3.000E+00	0.000E+00
124	'KRL14-12'	'ROLLER 8IN 95010005-12'	1.400E+01		'RUBBER'	3.750E+00	3.000E+00	0.000E+00
125	'BAR14-13'	'BAR 0.625 95010005-13'	1.340E+01		'A36'	3.750E+00	3.000E+00	0.000E+00
TOTAL			3.580E+01			3.750E+00	3.000E+00	0.000E+00

4 Items Processed.

GROUP: 10 'ASS-MISC'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
126	'BAR---13'	'BAR 4.00 95010002-13'	1.000E+01		'FY50'	6.667E+00	2.000E+00	0.000E+00
127	'CASING15'	'TUBE 14.25 95010002-15'	3.534E+01		'FY50'	3.177E-01	5.000E+00	0.000E+00
128	'CASING16'	'TUBE 14.00 95010002-16'	4.114E+01		'FY50'	5.365E-01	1.000E+00	0.000E+00
129	'STIFF-18'	'STF 0.500 95010002-18'	2.400E+01		'FY50'	2.865E-01	5.000E+00	0.000E+00
130	'STIFF-19'	'STF 0.500 95010002-19'	2.400E+01		'FY50'	2.865E-01	5.000E+00	0.000E+00
131	'STIFF-20'	'STF 0.500 95010002-20'	2.000E+01		'FY50'	2.865E-01	1.000E+00	0.000E+00
132	'STIFF-21'	'STF 0.500 95010002-21'	2.000E+01		'FY50'	2.865E-01	1.000E+00	0.000E+00
133	'ENDPL-22'	'PLT 0.625 95010002-22'	1.807E+02		'FY50'	0.000E+00	4.000E+00	0.000E+00
134	'PLATE-23'	'PLT 0.500 95010002-23'	1.600E+01		'FY50'	7.396E-01	5.000E+00	0.000E+00
135	'PLATE-24'	'PLT 0.500 95010002-24'	1.800E+01		'FY50'	7.396E-01	1.000E+00	0.000E+00
136	'FUNPL-25'	'FUNNEL 0.5 95010002-25'	8.890E+01		'FY50'	0.000E+00	4.000E+00	0.000E+00
137	'RING--28'	'RING 95010002-28'	1.000E+01		'FY50'	7.396E-01	5.000E+00	0.000E+00
138	'PLATE-XX'	'PLATE 0.500 THK '	8.160E+01		'FY50'	1.000E+00	3.000E+00	0.000E+00
139	'GUILLPLT'	'GUILLOTINE 2.25 THK '	1.320E+02		'FY50'	1.000E+00	1.000E+00	0.000E+00
140	'GUILLPLT'	'GUILLOTINE 2.25 THK '	1.320E+02		'FY50'	1.000E+00	5.000E+00	0.000E+00
TOTAL			8.337E+02			6.037E-01	3.336E+00	0.000E+00

15 Items Processed.

GROUP: 12 'PIN-CASE'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
141	'TUBE--03'	'TUBE 15.75 95010004-3 '	1.053E+02		'FY50'	0.000E+00	5.000E+00	0.000E+00
142	'BAR---04'	'BAR 13.00 95010004-4 '	2.800E+01		'FY50'	0.000E+00	5.000E+00	0.000E+00
143	'BAR---05'	'BAR 15.75 95010004-5 '	5.500E+01		'FY50'	0.000E+00	5.000E+00	0.000E+00
144	'TUBE--06'	'TUBE 15.75 95010004-6 '	1.900E+01		'FY50'	0.000E+00	5.000E+00	0.000E+00
145	'BAR---07'	'BAR 0.75 95010004-7 '	7.500E-01		'FY50'	0.000E+00	5.000E+00	0.000E+00
TOTAL			2.080E+02			0.000E+00	5.000E+00	0.000E+00

5 Items Processed.

GROUP: 13 'PIN-NOSE'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
146	'TUBE--09'	'TUBE 15.00 95010004-9 '	2.931E+01		'FY50'	0.000E+00	5.000E+00	0.000E+00
147	'PIPE--10'	'PIPE 12.00 95010004-10'	1.138E+02		'FY50'	0.000E+00	5.000E+00	0.000E+00
148	'TUBE--11'	'TUBE 12.75 95010004-11'	7.700E+01		'FY50'	0.000E+00	5.000E+00	0.000E+00
149	'TUBE--12'	'TUBE 12.75 95010004-12'	2.700E+01		'FY50'	0.000E+00	5.000E+00	0.000E+00
150	'BAR---13'	'BAR 12.75 95010004-13'	2.480E+02		'FY50'	0.000E+00	5.000E+00	0.000E+00
151	'PLT---14'	'BAR 11.75 95010004-14'	1.140E+01		'FY50'	0.000E+00	5.000E+00	0.000E+00
TOTAL			5.064E+02			0.000E+00	5.000E+00	0.000E+00

6 Items Processed.

GROUP: 14 'PIN-MISC'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
152	'PINCAP15'	'CAP 12.75 95010004-15'	3.000E+01		'PVC'	0.000E+00	5.000E+00	0.000E+00
153	'PINROD19'	'ROD 95010004-19'	1.626E+01		'FY50'	0.000E+00	5.000E+00	0.000E+00
154	'PINNUT20'	'NUT HEX 95010004-20'	5.000E-01		'SAEGR2'	0.000E+00	5.000E+00	0.000E+00
155	'SPRING21'	'SPRING 95010004-21'	1.877E+02		'FY50'	0.000E+00	5.000E+00	0.000E+00
156	'PINPLT22'	'PIN PLATE 95010004-22'	3.987E+00		'FY50'	0.000E+00	5.000E+00	0.000E+00
TOTAL			2.384E+02			0.000E+00	5.000E+00	0.000E+00

5 Items Processed.

GROUP: 16 'ENC-BHDS'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
157	'BHDPLT	'BHD PLT 0.25 THK '	1.183E+03		'FY50'	0.000E+00	3.000E+00	0.000E+00
158	'BHD-L4X3'	'BHD STF L4X3X3/8 '	7.677E+02		'FY50'	0.000E+00	3.000E+00	0.000E+00
159	'CRNR-PLT'	'STIFF 0.50 THK '	6.120E+01		'FY50'	0.000E+00	3.000E+00	0.000E+00

TOTAL			2.012E+03			0.000E+00	3.000E+00	0.000E+00

3 Items Processed.

GROUP: 17 'ENC--BMS'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
160	'TS6X4BOT'	'TS6X4X.500 '	1.421E+02		'FY50'	0.000E+00	3.000E+00	0.000E+00
161	'TS6X4TOP'	'TS6X4X.500 '	1.042E+02		'FY50'	0.000E+00	3.000E+00	0.000E+00
162	'TS6X2TOP'	'TS6X2X.375 '	6.332E+01		'FY50'	0.000E+00	3.000E+00	0.000E+00
163	'TS6X4SID'	'TS6X4X.500 '	4.549E+02		'FY50'	0.000E+00	3.000E+00	0.000E+00
164	'TS6X2SID'	'TS6X2X.375 '	2.763E+02		'FY50'	0.000E+00	3.000E+00	0.000E+00
165	'PADEYES8'	'PADEYE '	6.000E+01		'FY50'	0.000E+00	3.000E+00	0.000E+00
166	'PIN/NUT4'	'PIN&NUT '	2.000E+01		'FY50'	0.000E+00	3.000E+00	0.000E+00
TOTAL			1.121E+03			0.000E+00	3.000E+00	0.000E+00

7 Items Processed.

GROUP: 18 'ENC-CONN'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
167	'STFPLT24'	'STF PLT 0.500 THK '	5.000E+01		'FY50'	0.000E+00	3.000E+00	0.000E+00
168	'BRGPLT-8'	'BRG PLT 0.250 THK '	5.000E+01		'FY50'	0.000E+00	3.000E+00	0.000E+00
169	'SHIMPLTS'	'SHIMS VARY THK '	3.000E+01		'FY50'	0.000E+00	3.000E+00	0.000E+00
TOTAL			1.300E+02			0.000E+00	3.000E+00	0.000E+00

3 Items Processed.

*** 3 Item Identifiers Processed.

PRINT MTO LEV 2 GROUP 'MATERIAL'

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**************************************
*  PRINT OUTPUT FROM ASADS DATABASE  *
*  UNITS: FEET   LB  SEC  DEG DEGF   *
**************************************
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WEIGHT REPORT:
LEVEL 3,   1 GROUPS

WTO LEVEL 0 GROUPS: 1

WTO LEVEL 1 GROUPS: 1

GROUP NO.	GROUP ID	GROUP TITLE	GROUP WEIGHT	GROUP LENGTH	GROUP MATL	COG X	COG Y	COG Z
27	'MATERIAL'		6.835E+03	1.369E+02		7.666E-01	3.396E+00	0.000E+00
TOTAL			6.835E+03	1.369E+02		7.666E-01	3.396E+00	0.000E+00

169 Items Processed.

WTO LEVEL 2 GROUPS: 1

GROUP: 27   'MATERIAL'

GROUP NO.	GROUP ID	GROUP TITLE	GROUP WEIGHT	GROUP LENGTH	GROUP MATL	COG X	COG Y	COG Z
21	'FY50'		6.725E+03	1.369E+02		7.155E-01	3.394E+00	0.000E+00
22	'A36'		5.722E+01			5.984E+00	3.000E+00	0.000E+00
23	'SAEGR2'		6.300E+00			3.545E+00	3.159E+00	0.000E+00
24	'ZINCPL'		2.900E+00			3.851E+00	3.000E+00	0.000E+00
25	'RUBBER'		1.400E+01			3.750E+00	3.000E+00	0.000E+00
26	'PVC'		3.000E+01			0.000E+00	5.000E+00	0.000E+00
TOTAL			6.835E+03	1.369E+02		7.666E-01	3.396E+00	0.000E+00

169 Items Processed.

***   1 Item   Identifiers   Processed.

FIN

PROGRAM   ASADS V2.0 COMPLETED.

*** NUMBER OF JOINTS   :   72
*** NUMBER OF MEMBERS   :   122
*** NUMBER OF LOAD CASES: 38
*** NUMBER OF ITEMS   :   169

*** ERROR MESSAGES: 0
*** WARNING MESSAGES: 0

*** INPUT   FILE: REV4MTO
*** OUTPUT FILE: REV4MTO.OUT

```
*** SAVE    FILE : NONE GIVEN    RUN DATE/TIME: 25-Jan-1996 16:51:18
*** RESTORE FILE : REV4STIF.SAV  RUN DATE/TIME: 22-Dec-1995 16:19:39

*** RUN DATE/TIME : 25-Jan-1996 16:51:18
*** EXECUTION TIME:       46.91 SEC.
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C.2 LONGER PIN CONNECTION SYSTEM CONCEPT

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            A       SSSSS       A      DDDDD      SSSSS
           A A     S     S     A A     D    D    S     S
          A   A    S          A   A    D    D    S
         AAAAAAA    SSSSS    AAAAAAA   D    D    SSSSS
        A       A        S  A       A  D    D         S
       A       A  S     S  A       A  D    D   S     S
      A       A   SSSSS   A       A  DDDDD      SSSSS

         Advanced Structures Analysis and Design System
         =        =          =            =      =
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                    I.D.E.A.S.   ASADS
                       VERSION: V2.0
                    (   JULY 31, 1995    )

LICENSED TO: I.D.E.A.S., Inc.                         SER: IDEA-001
RUN DATE/TIME: 25-Jan-1996  17:36:51
 _
| |
|I|nternational          300 MONTGOMERY STREET
|D|esign,                SUITE 789B
|E|ngineering and        SAN FRANCISCO, CA  94104
|A|nalysis
|S|ervices, Inc.         TELEPHONE: (415) 362-7997
|_|                      TELEFAX:   (415) 362-7994
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==================================================================================================================================
=                                                                                                                                =
=                                          A S A D S    D E F A U L T    V A L U E S                                             =
=                                                                                                                                =
=                                  MEMBER CONSTANTS                          WATER CONSTANTS                                     =
=                                  ----------------                          ---------------                                     =
=   UNITS: LENGTH = INCHES         WEIGHT DENSITY      = 0.2836   LB/IN**3    MASS DENSITY        = 9.60 E-5 (LB-SEC**2)/IN**4   =
=          FORCE  = POUNDS         ELASTIC MODULUS     = 2.900 E7 LB/IN**2    KINEMATIC VISCOSITY = 2.03 E-3 IN**2/SEC           =
=          TIME   = SECONDS        SHEAR MODULUS       = 1.115 E7 LB/IN**2    TEMPERATURE         = 50.0     DEGREES FAHR        =
=          ANGLE  = RADIANS        COEF. OF THER. EXP. = 6.50 E-6 1/DEG-F                                                        =
=          TEMP   = DEG FAHR       BETA ANGLE          = 0.0      RADIANS     MAX NO. OF JOINTS   =  150 LOAD CASES    =   100   =
=                                  POISSON'S RATIO     = 0.30                 MAX NO. OF MEMBERS  =  450 MEM SEG PROPS =  2250   =
=                                  MATERIAL            = STEEL A36            MAX NO. OF EIGVALS  =    1 SOIL STRATA   =     3   =
=                                                                             MAX NO. OF SUBSTRUC =   10 BOUND NODES   =    50   =
==================================================================================================================================
```

```
*** INPUT FILE:  REV3MTO
*** OUTPUT FILE: REV3MTO.OUT
```


```
*** INPUT FILE:  REV3MTO
*** OUTPUT FILE: REV3MTO.OUT
```

```
**************************************
*  PRINT OUTPUT FROM ASADS DATABASE  *
*  UNITS: INCH  KIP  SEC  DEG DEGF   *
**************************************

     **************************************************
     *  SPECIFIED UNITS: INCH  KIP  SEC  DEG DEGF     *
     **************************************************


 UNITS LBS INCH
     ***Units Reset To:  INCH   LB  SEC  DEG DEGF

 CONSTANTS
     **************************************************
     *  SPECIFIED UNITS: INCH   LB  SEC  DEG DEGF     *
     **************************************************

 ALL  FY  50000.


 INACTIVE MEM ALL
     ***  122 Member  Identifiers     Processed.
 ACTIVE MEM -
    1101 1105 1201 1205 1305 1306 -
    2101 2105 2201 2205           -
    3101      3201                3303 TO 3308 3312 TO 3314 -
    5101 5105 5201 5205           5303 TO 5314 -
    1016 1026 2016 2026 3016 3026
     ***   43 Member  Identifiers     Processed.
 GENERATE ITEM
     ***   43 Item    Identifiers     Generated.
 ESTABLISH ITEM GROUP 'TS3X2' IDE ALL
     ***   ITEM GROUP Group   1 Processed For  43 IDs.


 INACTIVE MEM ALL
     ***  122 Member  Identifiers     Processed.
 INACTIVE ITEMS ALL
     ***   43 Item    Identifiers     Processed.
 ACTIVE MEM -
    1013 1014 1023 1024 -
    2013 2014 2023 2024 -
    3013 3014 3023 3024 -
    4013 4014 4023 4024
     ***   16 Member  Identifiers     Processed.
 GENERATE ITEM
     ***   16 Item    Identifiers     Generated.
 ESTABLISH ITEM GROUP 'TS4X2' IDE ALL
     ***   ITEM GROUP Group   2 Processed For  16 IDs.


 INACTIVE MEM ALL
     ***  122 Member  Identifiers     Processed.
```

```
 INACTIVE ITEMS ALL
     ***   59 Item    Identifiers     Processed.
 ACTIVE MEM -
    3309 TO 3311
     ***    3 Member  Identifiers     Processed.
 GENERATE ITEM
     ***    3 Item    Identifiers     Generated.
 ESTABLISH ITEM GROUP 'TS4X3' IDE ALL
     ***   ITEM GROUP Group   3 Processed For   3 IDs.


 INACTIVE MEM ALL
     ***  122 Member  Identifiers     Processed.
 INACTIVE ITEMS ALL
     ***   62 Item    Identifiers     Processed.
 ACTIVE MEM -
    2102 TO 2104 2202 TO 2204 -
    4102 TO 4104 4202 TO 4204
     ***   12 Member  Identifiers     Processed.
 GENERATE ITEM
     ***   12 Item    Identifiers     Generated.
 ESTABLISH ITEM GROUP 'TS5X2' IDE ALL
     ***   ITEM GROUP Group   4 Processed For  12 IDs.


 INACTIVE MEM ALL
     ***  122 Member  Identifiers     Processed.
 INACTIVE ITEMS ALL
     ***   74 Item    Identifiers     Processed.
 ACTIVE MEM -
    1102 TO 1104 1202 TO 1204 -
    5102 TO 5104 5202 TO 5204 -
    1015 1025 2015 2025 3015 3025 4015 4025
     ***   20 Member  Identifiers     Processed.
 GENERATE ITEM
     ***   20 Item    Identifiers     Generated.
 ESTABLISH ITEM GROUP 'TS6X2' IDE ALL
     ***   ITEM GROUP Group   5 Processed For  20 IDs.


 INACTIVE MEM ALL
     ***  122 Member  Identifiers     Processed.
 INACTIVE ITEMS ALL
     ***   94 Item    Identifiers     Processed.
 ACTIVE MEM -
    1302 2302 3302 5302 -
    1012 1022 2012 2022 3012 3022 4012 4022
     ***   12 Member  Identifiers     Processed.
 GENERATE ITEM
     ***   12 Item    Identifiers     Generated.
 ESTABLISH ITEM GROUP 'TS6X4' IDE ALL
     ***   ITEM GROUP Group   6 Processed For  12 IDs.


 INACTIVE MEM ALL
```

```
    ***  122 Member  Identifiers     Processed.
INACTIVE ITEMS ALL
    ***  106 Item    Identifiers     Processed.
ACTIVE MEM -
   3102 3103 3202 3203 -
   5401 TO 5404
    ***    8 Member  Identifiers     Processed.
GENERATE ITEM
    ***    8 Item    Identifiers     Generated.
ESTABLISH ITEM GROUP 'L4X3' IDE ALL
    ***   ITEM GROUP Group   7 Processed For   8 IDs.


$ NON-MODELED ITEMS
INACTIVE ITEMS ALL
    ***  114 Item    Identifiers     Processed.
DEFINE ITEM 'BAR---03'  WEI  31.569  X 80.0000  Y  36.000  Z  0.000  -
       TITLE 'BAR  2.500 95010005-3 ' MAT 'A36'
DEFINE ITEM 'BAR---04'  WEI   2.339  X 80.0000  Y  36.000  Z  0.000  -
       TITLE 'BAR  2.000 95010005-4 ' MAT 'A36'
DEFINE ITEM 'BAR4--05'  WEI   1.559  X 80.0000  Y  36.000  Z  0.000  -
       TITLE 'BAR  0.500 95010005-5 ' MAT 'A36'
DEFINE ITEM 'BAR---07'  WEI   3.563  X 80.0000  Y  36.000  Z  0.000  -
       TITLE 'BAR  1.000 95010005-7 ' MAT 'A36'
DEFINE ITEM 'WASH2-08'  WEI   0.100  X 80.0000  Y  36.000  Z  0.000  -
       TITLE 'WASH 1.75  95010005-8 ' MAT 'ZINCPL'
DEFINE ITEM 'NUTS2-09'  WEI   0.200  X 80.0000  Y  36.000  Z  0.000  -
       TITLE 'NUTS HEX   95010005-9 ' MAT 'SAEGR2'
DEFINE ITEM 'LVRSHF10'  WEI   4.788  X 80.0000  Y  36.000  Z  0.000  -
       TITLE 'LEVER 1.00 95010005-10' MAT 'A36'
ESTABLISH ITEM GROUP 'ASS-LEVR' IDE ALL
    ***   ITEM GROUP Group   8 Processed For   7 IDs.


INACTIVE ITEMS ALL
    ***  121 Item    Identifiers     Processed.
DEFINE ITEM 'WAS40-08'  WEI   4.000  X 45.0000  Y  36.000  Z  0.000  -
       TITLE 'WASH  1.75 95010005-8 ' MAT 'ZINCPL'
DEFINE ITEM 'NUT40-09'  WEI   8.000  X 45.0000  Y  36.000  Z  0.000  -
       TITLE 'NUT HEX    95010005-9 ' MAT 'SAEGR2'
DEFINE ITEM 'KRL28-12'  WEI  20.000  X 45.0000  Y  36.000  Z  0.000  -
       TITLE 'ROLLER 8IN 95010005-12' MAT 'RUBBER'
DEFINE ITEM 'BAR28-13'  WEI  19.139  X 45.0000  Y  36.000  Z  0.000  -
       TITLE 'BAR  0.625 95010005-13' MAT 'A36'
ESTABLISH ITEM GROUP 'ASS-ROLL' IDE ALL
    ***   ITEM GROUP Group   9 Processed For   4 IDs.

INACTIVE ITEMS ALL
    ***  125 Item    Identifiers     Processed.


INACTIVE ITEMS ALL
    ***  125 Item    Identifiers     Processed.
DEFINE ITEM 'BAR---13'  WEI  10.000  X 80.0000  Y  24.000  Z  0.000 -
       TITLE 'BAR  4.00  95010002-13' MAT 'FY50'
```

```
 DEFINE ITEM 'CASING15'  WEI  35.343  X  3.8125  Y  60.000  Z  0.000 -
        TITLE 'TUBE 14.25 95010002-15' MAT 'FY50'
 DEFINE ITEM 'CASING16'  WEI  41.137  X  6.4375  Y  12.000  Z  0.000 -
        TITLE 'TUBE 14.25 95010002-16' MAT 'FY50'
 DEFINE ITEM 'STIFF-18'  WEI  24.0    X  3.4375  Y  60.000  Z  0.000 -
        TITLE 'STF  0.500 95010002-18' MAT 'FY50'
 DEFINE ITEM 'STIFF-19'  WEI  24.0    X  3.4375  Y  60.000  Z  0.000 -
        TITLE 'STF  0.500 95010002-19' MAT 'FY50'
 DEFINE ITEM 'STIFF-20'  WEI  20.0    X  3.4375  Y  12.000  Z  0.000 -
        TITLE 'STF  0.500 95010002-20' MAT 'FY50'
 DEFINE ITEM 'STIFF-21'  WEI  20.0    X  3.4375  Y  12.000  Z  0.000 -
        TITLE 'STF  0.500 95010002-21' MAT 'FY50'
 DEFINE ITEM 'ENDPL-22'  WEI 180.7    X  0.000   Y  48.000  Z  0.000 -
        TITLE 'PLT  0.625 95010002-22' MAT 'FY50'
 DEFINE ITEM 'PLATE-23'  WEI  16.0    X  8.875   Y  60.000  Z  0.000 -
        TITLE 'PLT  0.500 95010002-23' MAT 'FY50'
 DEFINE ITEM 'PLATE-24'  WEI  18.0    X  8.875   Y  12.000  Z  0.000 -
        TITLE 'PLT  0.500 95010002-24' MAT 'FY50'
 DEFINE ITEM 'FUNPL-25'  WEI  88.9    X  0.000   Y  48.000  Z  0.000 -
        TITLE 'FUNNEL 0.5 95010002-25' MAT 'FY50'
 DEFINE ITEM 'RING--28'  WEI  10.0    X  8.875   Y  60.000  Z  0.000 -
        TITLE 'RING       95010002-28' MAT 'FY50'
 DEFINE ITEM 'PLATE-XX'  WEI  81.6    X 12.000   Y  36.000  Z  0.000 -
        TITLE 'PLATE 0.500 THK       ' MAT 'FY50'
 DEFINE ITEM 'GUILLPLT'  WEI 132.0    X 12.000   Y  12.000  Z  0.000 -
        TITLE 'GUILLOTINE 2.25 THK   ' MAT 'FY50'
 DEFINE ITEM 'GUILLPLT'  WEI 132.0    X 12.000   Y  60.000  Z  0.000 -
        TITLE 'GUILLOTINE 2.25 THK   ' MAT 'FY50'
 ESTABLISH ITEM GROUP 'ASS-MISC' IDE ALL
     ***   ITEM GROUP Group  10 Processed For  15 IDs.


 ACTIVE ITEMS ALL
     ***  140 Item    Identifiers     Processed.
 ESTABLISH ITEM GROUP 'ASSEMBLY' GROUPS -
    'TS3X2'  'TS4X2' 'TS4X3' 'TS5X2' 'TS6X2' 'TS6X4' 'L4X3' -
    'ASS-LEVR'  'ASS-ROLL'  'ASS-MISC'
     ***   ITEM GROUP Group  11 Processed For 140 IDs.



 INACTIVE ITEMS ALL
     ***  140 Item    Identifiers     Processed.
 DEFINE ITEM 'TUBE--03'  WEI 171.000  X  0.0000  Y  60.000  Z  0.000 -
        TITLE 'TUBE 15.75 95010004-3 ' MAT 'FY50'
 DEFINE ITEM 'BAR---04'  WEI  28.000  X  0.0000  Y  60.000  Z  0.000 -
        TITLE 'BAR  13.00 95010004-4 ' MAT 'FY50'
 DEFINE ITEM 'BAR---05'  WEI  55.000  X  0.0000  Y  60.000  Z  0.000 -
        TITLE 'BAR  15.75 95010004-5 ' MAT 'FY50'
 DEFINE ITEM 'TUBE--06'  WEI  19.000  X  0.0000  Y  60.000  Z  0.000 -
        TITLE 'TUBE 15.75 95010004-6 ' MAT 'FY50'
 DEFINE ITEM 'BAR---07'  WEI   0.750  X  0.0000  Y  60.000  Z  0.000 -
        TITLE 'BAR   0.75 95010004-7 ' MAT 'FY50'
 ESTABLISH ITEM GROUP 'PIN-CASE' IDE ALL
```

```
    ***   ITEM GROUP Group  12 Processed For   5 IDs.



 INACTIVE ITEMS ALL
    ***  145 Item    Identifiers     Processed.
 DEFINE ITEM 'TUBE--09'  WEI  29.310  X  0.0000  Y  60.000  Z  0.000 -
       TITLE 'TUBE 15.00 95010004-9 ' MAT 'FY50'
 DEFINE ITEM 'PIPE--10'  WEI  65.000  X  0.0000  Y  60.000  Z  0.000 -
       TITLE 'PIPE 12.00 95010004-10' MAT 'FY50'
 DEFINE ITEM 'TUBE--11'  WEI  44.000  X  0.0000  Y  60.000  Z  0.000 -
       TITLE 'TUBE 12.75 95010004-11' MAT 'FY50'
 DEFINE ITEM 'TUBE--12'  WEI  27.000  X  0.0000  Y  60.000  Z  0.000 -
       TITLE 'TUBE 12.75 95010004-12' MAT 'FY50'
 DEFINE ITEM 'BAR---13'  WEI 247.980  X  0.0000  Y  60.000  Z  0.000 -
       TITLE 'BAR  12.75 95010004-13' MAT 'FY50'
 DEFINE ITEM 'PLT---14'  WEI  11.400  X  0.0000  Y  60.000  Z  0.000 -
       TITLE 'BAR  11.75 95010004-14' MAT 'FY50'
 DEFINE ITEM 'BRGPLTS '  WEI  38.600  X  0.0000  Y  60.000  Z  0.000 -
       TITLE 'BAR  11.75 X 0.5 THK  ' MAT 'FY50'
 ESTABLISH ITEM GROUP 'PIN-NOSE' IDE ALL
    ***   ITEM GROUP Group  13 Processed For   7 IDs.



 INACTIVE ITEMS ALL
    ***  152 Item    Identifiers     Processed.
 DEFINE ITEM 'PINCAP15'  WEI  30.000  X  0.0000  Y  60.000  Z  0.000 -
       TITLE 'CAP  12.75 95010004-15' MAT 'PVC'
 DEFINE ITEM 'PINROD19'  WEI  16.258  X  0.0000  Y  60.000  Z  0.000 -
       TITLE 'ROD        95010004-19' MAT 'FY50'
 DEFINE ITEM 'PINNUT20'  WEI   0.500  X  0.0000  Y  60.000  Z  0.000 -
       TITLE 'NUT HEX    95010004-20' MAT 'SAEGR2'
 DEFINE ITEM 'SPRING21'  WEI 187.700  X  0.0000  Y  60.000  Z  0.000 -
       TITLE 'SPRING     95010004-21' MAT 'FY50'
 DEFINE ITEM 'PINPLT22'  WEI   3.987  X  0.0000  Y  60.000  Z  0.000 -
       TITLE 'PIN PLATE  95010004-22' MAT 'FY50'
 ESTABLISH ITEM GROUP 'PIN-MISC' IDE ALL
    ***   ITEM GROUP Group  14 Processed For   5 IDs.


 ACTIVE ITEMS ALL
    ***  157 Item    Identifiers     Processed.
 ESTABLISH ITEM GROUP 'STAB-PIN' GROUPS -
    'PIN-CASE' 'PIN-NOSE' 'PIN-MISC'
    ***   ITEM GROUP Group  15 Processed For  17 IDs.


 $ BARGE SUPPORT STRUCTURE
 INACTIVE ITEMS ALL
    ***  157 Item    Identifiers     Processed.
 DEFINE ITEM 'BHDPLT  '  WEI 1428.000  X  0.0000  Y  36.000  Z  0.000 -
       TITLE 'BHD PLT 0.25 THK      ' MAT 'FY50'
 DEFINE ITEM 'BHD-L4X3'  WEI  926.000  X  0.0000  Y  36.000  Z  0.000 -
       TITLE 'BHD STF L4X3X3/8      ' MAT 'FY50'
 DEFINE ITEM 'CRNR-PLT'  WEI   61.200  X  0.0000  Y  36.000  Z  0.000 -
```

```
       TITLE 'STIFF 0.50 THK        ' MAT 'FY50'
 ESTABLISH ITEM GROUP 'ENC-BHDS' IDE ALL
     ***   ITEM GROUP Group  16 Processed For   3 IDs.


 INACTIVE ITEMS ALL
     ***  160 Item    Identifiers     Processed.
 DEFINE ITEM 'TS6X4BOT'  WEI  142.150  X  0.0000  Y  36.000  Z  0.000 -
       TITLE 'TS6X4X.500            ' MAT 'FY50'
 DEFINE ITEM 'TS6X4TOP'  WEI  104.243  X  0.0000  Y  36.000  Z  0.000 -
       TITLE 'TS6X4X.500            ' MAT 'FY50'
 DEFINE ITEM 'TS6X2TOP'  WEI   63.323  X  0.0000  Y  36.000  Z  0.000 -
       TITLE 'TS6X2X.375            ' MAT 'FY50'
 DEFINE ITEM 'TS6X4SID'  WEI  454.880  X  0.0000  Y  36.000  Z  0.000 -
       TITLE 'TS6X4X.500            ' MAT 'FY50'
 DEFINE ITEM 'TS6X2SID'  WEI  276.320  X  0.0000  Y  36.000  Z  0.000 -
       TITLE 'TS6X2X.375            ' MAT 'FY50'
 DEFINE ITEM 'PADEYES8'  WEI   60.000  X  0.0000  Y  36.000  Z  0.000 -
       TITLE 'PADEYE                ' MAT 'FY50'
 DEFINE ITEM 'PIN/NUT4'  WEI   20.000  X  0.0000  Y  36.000  Z  0.000 -
       TITLE 'PIN&NUT               ' MAT 'FY50'
 ESTABLISH ITEM GROUP 'ENC--BMS' IDE ALL
     ***   ITEM GROUP Group  17 Processed For   7 IDs.


 INACTIVE ITEMS ALL
     ***  167 Item    Identifiers     Processed.
 DEFINE ITEM 'STFPLT24'  WEI   50.000  X  0.0000  Y  36.000  Z  0.000 -
       TITLE 'STF PLT 0.500 THK     ' MAT 'FY50'
 DEFINE ITEM 'BRGPLT-8'  WEI   50.000  X  0.0000  Y  36.000  Z  0.000 -
       TITLE 'BRG PLT 0.250 THK     ' MAT 'FY50'
 DEFINE ITEM 'SHIMPLTS'  WEI   30.000  X  0.0000  Y  36.000  Z  0.000 -
       TITLE 'SHIMS VARY THK        ' MAT 'FY50'
 ESTABLISH ITEM GROUP 'ENC-CONN' IDE ALL
     ***   ITEM GROUP Group  18 Processed For   3 IDs.


 ACTIVE ITEMS ALL
     ***  170 Item    Identifiers     Processed.
 ESTABLISH ITEM GROUP 'ENC-SPPT' GROUPS -
    'ENC-BHDS' 'ENC--BMS' 'ENC-CONN'
     ***   ITEM GROUP Group  19 Processed For  13 IDs.



 ACTIVE ITEMS ALL
     ***  170 Item    Identifiers     Processed.
 ESTABLISH ITEM GROUP 'LONGPIN' GROUPS -
    'ASSEMBLY'  'STAB-PIN'  'ENC-SPPT'
     ***   ITEM GROUP Group  20 Processed For 170 IDs.



 ESTABLISH ITEM GROUP 'FY50'   MATERIAL 'FY50'
```

```
    ***              Group  21 Processed For 157 IDs.

 ESTABLISH ITEM GROUP 'A36'    MATERIAL 'A36'
    ***              Group  22 Processed For   6 IDs.

 ESTABLISH ITEM GROUP 'SAEGR2' MATERIAL 'SAEGR2'
    ***              Group  23 Processed For   3 IDs.

 ESTABLISH ITEM GROUP 'ZINCPL' MATERIAL 'ZINCPL'
    ***              Group  24 Processed For   2 IDs.

 ESTABLISH ITEM GROUP 'RUBBER' MATERIAL 'RUBBER'
    ***              Group  25 Processed For   1 IDs.

 ESTABLISH ITEM GROUP 'PVC'    MATERIAL 'PVC'
    ***              Group  26 Processed For   1 IDs.

 ESTABLISH ITEM GROUP 'MATERIAL' GROUP -
   'FY50' 'A36' 'SAEGR2' 'ZINCPL' 'RUBBER' 'PVC'
    ***   ITEM GROUP Group  27 Processed For 170 IDs.


 UNITS LBS FEET
    ***Units Reset To:  FEET   LB  SEC  DEG DEGF

 ACTIVE ITEMS ALL
    ***  170 Item    Identifiers     Processed.
 PRINT MTO LEV 4 GROUP 'LONGPIN'
```

```
*************************************
*  PRINT OUTPUT FROM ASADS DATABASE  *
*  UNITS: FEET   LB  SEC  DEG DEGF   *
*************************************
```

WEIGHT REPORT:
LEVEL 5, 1 GROUPS

WTO LEVEL 0 GROUPS: 1

WTO LEVEL 1 GROUPS: 1

GROUP NO.	GROUP ID	GROUP TITLE	GROUP WEIGHT	GROUP LENGTH	GROUP MATL	COG X	COG Y	COG Z
20	'LONGPIN'		7.520E+03	1.559E+02		9.842E-01	3.385E+00	0.000E+00
TOTAL			7.520E+03	1.559E+02		9.842E-01	3.385E+00	0.000E+00

170 Items Processed.

WTO LEVEL 2 GROUPS: 1

GROUP: 20 'LONGPIN'

GROUP NO.	GROUP ID	GROUP TITLE	GROUP WEIGHT	GROUP LENGTH	GROUP MATL	COG X	COG Y	COG Z
11	'ASSEMBLY'		2.878E+03	1.559E+02		2.572E+00	3.328E+00	0.000E+00
15	'STAB-PIN'		9.755E+02			0.000E+00	5.000E+00	0.000E+00
19	'ENC-SPPT'		3.666E+03			0.000E+00	3.000E+00	0.000E+00
TOTAL			7.520E+03	1.559E+02		9.842E-01	3.385E+00	0.000E+00

170 Items Processed.

WTO LEVEL 3 GROUPS: 3

GROUP: 11 'ASSEMBLY'

GROUP NO.	GROUP ID	GROUP TITLE	GROUP WEIGHT	GROUP LENGTH	GROUP MATL	COG X	COG Y	COG Z
1	'TS3X2'		3.159E+02	4.442E+01		5.569E+00	3.301E+00	0.000E+00
2	'TS4X2'		1.983E+02	2.250E+01		3.083E+00	3.062E+00	0.000E+00
3	'TS4X3'		2.327E+01	1.833E+00		5.417E+00	4.125E+00	0.000E+00
4	'TS5X2'		2.242E+02	1.767E+01		3.123E+00	3.375E+00	0.000E+00
5	'TS6X2'		4.999E+02	2.892E+01		4.016E+00	3.062E+00	0.000E+00
6	'TS6X4'		4.907E+02	1.725E+01		7.500E-01	3.041E+00	0.000E+00
7	'L4X3'		1.969E+02	2.333E+01		4.265E+00	5.013E+00	0.000E+00
8	'ASS-LEVR'		4.412E+01			6.667E+00	3.000E+00	0.000E+00
9	'ASS-ROLL'		5.114E+01			3.750E+00	3.000E+00	0.000E+00
10	'ASS-MISC'		8.337E+02			6.037E-01	3.336E+00	0.000E+00

TOTAL			2.878E+03	1.559E+02		2.572E+00	3.328E+00	0.000E+00

140 Items Processed.

GROUP: 15 'STAB-PIN'

GROUP NO.	GROUP ID	GROUP TITLE	GROUP WEIGHT	GROUP LENGTH	GROUP MATL	COG X	COG Y	COG Z
12	'PIN-CASE'		2.738E+02			0.000E+00	5.000E+00	0.000E+00
13	'PIN-NOSE'		4.633E+02			0.000E+00	5.000E+00	0.000E+00
14	'PIN-MISC'		2.384E+02			0.000E+00	5.000E+00	0.000E+00
TOTAL			9.755E+02			0.000E+00	5.000E+00	0.000E+00

17 Items Processed.

GROUP: 19 'ENC-SPPT'

GROUP NO.	GROUP ID	GROUP TITLE	GROUP WEIGHT	GROUP LENGTH	GROUP MATL	COG X	COG Y	COG Z
16	'ENC-BHDS'		2.415E+03			0.000E+00	3.000E+00	0.000E+00
17	'ENC--BMS'		1.121E+03			0.000E+00	3.000E+00	0.000E+00
18	'ENC-CONN'		1.300E+02			0.000E+00	3.000E+00	0.000E+00
TOTAL			3.666E+03			0.000E+00	3.000E+00	0.000E+00

13 Items Processed.

WTO LEVEL 4 GROUPS: 16

GROUP: 1 'TS3X2'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
1	'M1101S1'	TS3X2X.250	4.149E+00	5.833E-01	'FY50'	3.750E-01	2.500E-01	9.167E-01
2	'M1105S1'	TS3X2X.250	1.422E+01	2.000E+00	'FY50'	6.458E+00	2.500E-01	9.167E-01
3	'M1201S1'	TS3X2X.250	4.149E+00	5.833E-01	'FY50'	3.750E-01	2.500E-01	-9.167E-01
4	'M1205S1'	TS3X2X.250	1.422E+01	2.000E+00	'FY50'	6.458E+00	2.500E-01	-9.167E-01
5	'M1305S1'	TS3X2X.250	1.304E+01	1.833E+00	'FY50'	5.417E+00	2.500E-01	0.000E+00
6	'M1306S1'	TS3X2X.250	1.304E+01	1.833E+00	'FY50'	7.500E+00	2.500E-01	0.000E+00
7	'M2101S1'	TS3X2X.250	4.149E+00	5.833E-01	'FY50'	3.750E-01	1.750E+00	9.167E-01
8	'M2105S1'	TS3X2X.250	1.422E+01	2.000E+00	'FY50'	6.458E+00	1.750E+00	9.167E-01
9	'M2201S1'	TS3X2X.250	4.149E+00	5.833E-01	'FY50'	3.750E-01	1.750E+00	-9.167E-01
10	'M2205S1'	TS3X2X.250	1.422E+01	2.000E+00	'FY50'	6.458E+00	1.750E+00	-9.167E-01
11	'M3101S1'	TS3X2X.250	4.149E+00	5.833E-01	'FY50'	3.750E-01	4.125E+00	9.167E-01
12	'M3201S1'	TS3X2X.250	4.149E+00	5.833E-01	'FY50'	3.750E-01	4.125E+00	-9.167E-01
13	'M3303S1'	TS3X2X.250	3.852E+00	5.417E-01	'FY50'	1.167E+00	4.125E+00	6.458E-01
14	'M3304S1'	TS3X2X.250	5.334E+00	7.500E-01	'FY50'	1.167E+00	4.125E+00	0.000E+00
15	'M3305S1'	TS3X2X.250	3.852E+00	5.417E-01	'FY50'	1.167E+00	4.125E+00	-6.458E-01
16	'M3306S1'	TS3X2X.250	3.852E+00	5.417E-01	'FY50'	5.000E+00	4.125E+00	6.458E-01
17	'M3307S1'	TS3X2X.250	5.334E+00	7.500E-01	'FY50'	5.000E+00	4.125E+00	0.000E+00
18	'M3308S1'	TS3X2X.250	3.852E+00	5.417E-01	'FY50'	5.000E+00	4.125E+00	-6.458E-01

19	'M3312S1'	TS3X2X.250	3.852E+00	5.417E-01	'FY50'	7.500E+00	4.125E+00	6.458E-01
20	'M3313S1'	TS3X2X.250	5.334E+00	7.500E-01	'FY50'	7.500E+00	4.125E+00	0.000E+00
21	'M3314S1'	TS3X2X.250	3.852E+00	5.417E-01	'FY50'	7.500E+00	4.125E+00	-6.458E-01
22	'M5101S1'	TS3X2X.250	4.149E+00	5.833E-01	'FY50'	3.750E-01	5.875E+00	9.167E-01
23	'M5105S1'	TS3X2X.250	1.422E+01	2.000E+00	'FY50'	6.458E+00	5.875E+00	9.167E-01
24	'M5201S1'	TS3X2X.250	4.149E+00	5.833E-01	'FY50'	3.750E-01	5.875E+00	-9.167E-01
25	'M5205S1'	TS3X2X.250	1.422E+01	2.000E+00	'FY50'	6.458E+00	5.875E+00	-9.167E-01
26	'M5303S1'	TS3X2X.250	3.852E+00	5.417E-01	'FY50'	1.167E+00	5.875E+00	6.458E-01
27	'M5304S1'	TS3X2X.250	5.334E+00	7.500E-01	'FY50'	1.167E+00	5.875E+00	0.000E+00
28	'M5305S1'	TS3X2X.250	3.852E+00	5.417E-01	'FY50'	1.167E+00	5.875E+00	-6.458E-01
29	'M5306S1'	TS3X2X.250	3.852E+00	5.417E-01	'FY50'	5.000E+00	5.875E+00	6.458E-01
30	'M5307S1'	TS3X2X.250	5.334E+00	7.500E-01	'FY50'	5.000E+00	5.875E+00	0.000E+00
31	'M5308S1'	TS3X2X.250	3.852E+00	5.417E-01	'FY50'	5.000E+00	5.875E+00	-6.458E-01
32	'M5309S1'	TS3X2X.250	3.852E+00	5.417E-01	'FY50'	5.417E+00	5.875E+00	6.458E-01
33	'M5310S1'	TS3X2X.250	5.334E+00	7.500E-01	'FY50'	5.417E+00	5.875E+00	0.000E+00
34	'M5311S1'	TS3X2X.250	3.852E+00	5.417E-01	'FY50'	5.417E+00	5.875E+00	-6.458E-01
35	'M5312S1'	TS3X2X.250	3.852E+00	5.417E-01	'FY50'	7.500E+00	5.875E+00	6.458E-01
36	'M5313S1'	TS3X2X.250	5.334E+00	7.500E-01	'FY50'	7.500E+00	5.875E+00	0.000E+00
37	'M5314S1'	TS3X2X.250	3.852E+00	5.417E-01	'FY50'	7.500E+00	5.875E+00	-6.458E-01
38	'M1016S1'	TS3X2X.250	1.067E+01	1.500E+00	'FY50'	7.500E+00	1.000E+00	9.167E-01
39	'M1026S1'	TS3X2X.250	1.067E+01	1.500E+00	'FY50'	7.500E+00	1.000E+00	-9.167E-01
40	'M2016S1'	TS3X2X.250	1.689E+01	2.375E+00	'FY50'	7.500E+00	2.938E+00	9.167E-01
41	'M2026S1'	TS3X2X.250	1.689E+01	2.375E+00	'FY50'	7.500E+00	2.938E+00	-9.167E-01
42	'M3016S1'	TS3X2X.250	1.245E+01	1.750E+00	'FY50'	7.500E+00	5.000E+00	9.167E-01
43	'M3026S1'	TS3X2X.250	1.245E+01	1.750E+00	'FY50'	7.500E+00	5.000E+00	-9.167E-01
TOTAL			3.159E+02	4.442E+01		5.569E+00	3.301E+00	0.000E+00

43 Items Processed.

GROUP: 2 'TS4X2'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
44	'M1013S1'	TS4X2X.250	1.322E+01	1.500E+00	'FY50'	1.167E+00	1.000E+00	9.167E-01
45	'M1014S1'	TS4X2X.250	1.322E+01	1.500E+00	'FY50'	5.000E+00	1.000E+00	9.167E-01
46	'M1023S1'	TS4X2X.250	1.322E+01	1.500E+00	'FY50'	1.167E+00	1.000E+00	-9.167E-01
47	'M1024S1'	TS4X2X.250	1.322E+01	1.500E+00	'FY50'	5.000E+00	1.000E+00	-9.167E-01
48	'M2013S1'	TS4X2X.250	2.093E+01	2.375E+00	'FY50'	1.167E+00	2.938E+00	9.167E-01
49	'M2014S1'	TS4X2X.250	2.093E+01	2.375E+00	'FY50'	5.000E+00	2.938E+00	9.167E-01
50	'M2023S1'	TS4X2X.250	2.093E+01	2.375E+00	'FY50'	1.167E+00	2.938E+00	-9.167E-01
51	'M2024S1'	TS4X2X.250	2.093E+01	2.375E+00	'FY50'	5.000E+00	2.938E+00	-9.167E-01
52	'M3013S1'	TS4X2X.250	7.712E+00	8.750E-01	'FY50'	1.167E+00	4.563E+00	9.167E-01
53	'M3014S1'	TS4X2X.250	7.712E+00	8.750E-01	'FY50'	5.000E+00	4.563E+00	9.167E-01
54	'M3023S1'	TS4X2X.250	7.712E+00	8.750E-01	'FY50'	1.167E+00	4.563E+00	-9.167E-01
55	'M3024S1'	TS4X2X.250	7.712E+00	8.750E-01	'FY50'	5.000E+00	4.563E+00	-9.167E-01
56	'M4013S1'	TS4X2X.250	7.712E+00	8.750E-01	'FY50'	1.167E+00	5.438E+00	9.167E-01
57	'M4014S1'	TS4X2X.250	7.712E+00	8.750E-01	'FY50'	5.000E+00	5.438E+00	9.167E-01
58	'M4023S1'	TS4X2X.250	7.712E+00	8.750E-01	'FY50'	1.167E+00	5.438E+00	-9.167E-01
59	'M4024S1'	TS4X2X.250	7.712E+00	8.750E-01	'FY50'	5.000E+00	5.438E+00	-9.167E-01

TOTAL			1.983E+02	2.250E+01		3.083E+00	3.062E+00	0.000E+00

16 Items Processed.

GROUP: 3 'TS4X3'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
60	'M3309S1'	TS4X3X.3125	6.875E+00	5.417E-01	'FY50'	5.417E+00	4.125E+00	6.458E-01
61	'M3310S1'	TS4X3X.3125	9.519E+00	7.500E-01	'FY50'	5.417E+00	4.125E+00	0.000E+00
62	'M3311S1'	TS4X3X.3125	6.875E+00	5.417E-01	'FY50'	5.417E+00	4.125E+00	-6.458E-01
TOTAL			2.327E+01	1.833E+00		5.417E+00	4.125E+00	0.000E+00

3 Items Processed.

GROUP: 4 'TS5X2'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
63	'M2102S1'	TS5X2X.3125	3.173E+00	2.500E-01	'FY50'	9.583E-01	1.750E+00	9.167E-01
64	'M2103S1'	TS5X2X.3125	4.865E+01	3.833E+00	'FY50'	3.083E+00	1.750E+00	9.167E-01
65	'M2104S1'	TS5X2X.3125	4.231E+00	3.333E-01	'FY50'	5.208E+00	1.750E+00	9.167E-01
66	'M2202S1'	TS5X2X.3125	3.173E+00	2.500E-01	'FY50'	9.583E-01	1.750E+00	-9.167E-01
67	'M2203S1'	TS5X2X.3125	4.865E+01	3.833E+00	'FY50'	3.083E+00	1.750E+00	-9.167E-01
68	'M2204S1'	TS5X2X.3125	4.231E+00	3.333E-01	'FY50'	5.208E+00	1.750E+00	-9.167E-01
69	'M4102S1'	TS5X2X.3125	3.173E+00	2.500E-01	'FY50'	9.583E-01	5.000E+00	9.167E-01
70	'M4103S1'	TS5X2X.3125	4.865E+01	3.833E+00	'FY50'	3.083E+00	5.000E+00	9.167E-01
71	'M4104S1'	TS5X2X.3125	4.231E+00	3.333E-01	'FY50'	5.208E+00	5.000E+00	9.167E-01
72	'M4202S1'	TS5X2X.3125	3.173E+00	2.500E-01	'FY50'	9.583E-01	5.000E+00	-9.167E-01
73	'M4203S1'	TS5X2X.3125	4.865E+01	3.833E+00	'FY50'	3.083E+00	5.000E+00	-9.167E-01
74	'M4204S1'	TS5X2X.3125	4.231E+00	3.333E-01	'FY50'	5.208E+00	5.000E+00	-9.167E-01
TOTAL			2.242E+02	1.767E+01		3.123E+00	3.375E+00	0.000E+00

12 Items Processed.

GROUP: 5 'TS6X2'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
75	'M1102S1'	TS6X2X.375	4.322E+00	2.500E-01	'FY50'	9.583E-01	2.500E-01	9.167E-01
76	'M1103S1'	TS6X2X.375	6.626E+01	3.833E+00	'FY50'	3.083E+00	2.500E-01	9.167E-01
77	'M1104S1'	TS6X2X.375	5.762E+00	3.333E-01	'FY50'	5.208E+00	2.500E-01	9.167E-01
78	'M1202S1'	TS6X2X.375	4.322E+00	2.500E-01	'FY50'	9.583E-01	2.500E-01	-9.167E-01
79	'M1203S1'	TS6X2X.375	6.626E+01	3.833E+00	'FY50'	3.083E+00	2.500E-01	-9.167E-01
80	'M1204S1'	TS6X2X.375	5.762E+00	3.333E-01	'FY50'	5.208E+00	2.500E-01	-9.167E-01
81	'M5102S1'	TS6X2X.375	4.322E+00	2.500E-01	'FY50'	9.583E-01	5.875E+00	9.167E-01
82	'M5103S1'	TS6X2X.375	6.626E+01	3.833E+00	'FY50'	3.083E+00	5.875E+00	9.167E-01
83	'M5104S1'	TS6X2X.375	5.762E+00	3.333E-01	'FY50'	5.208E+00	5.875E+00	9.167E-01
84	'M5202S1'	TS6X2X.375	4.322E+00	2.500E-01	'FY50'	9.583E-01	5.875E+00	-9.167E-01
85	'M5203S1'	TS6X2X.375	6.626E+01	3.833E+00	'FY50'	3.083E+00	5.875E+00	-9.167E-01
86	'M5204S1'	TS6X2X.375	5.762E+00	3.333E-01	'FY50'	5.208E+00	5.875E+00	-9.167E-01
87	'M1015S1'	TS6X2X.375	2.593E+01	1.500E+00	'FY50'	5.417E+00	1.000E+00	9.167E-01
88	'M1025S1'	TS6X2X.375	2.593E+01	1.500E+00	'FY50'	5.417E+00	1.000E+00	-9.167E-01

89	'M2015S1'	TS6X2X.375	4.105E+01	2.375E+00	'FY50'	5.417E+00	2.938E+00	9.167E-01
90	'M2025S1'	TS6X2X.375	4.105E+01	2.375E+00	'FY50'	5.417E+00	2.938E+00	-9.167E-01
91	'M3015S1'	TS6X2X.375	1.513E+01	8.750E-01	'FY50'	5.417E+00	4.563E+00	9.167E-01
92	'M3025S1'	TS6X2X.375	1.513E+01	8.750E-01	'FY50'	5.417E+00	4.563E+00	-9.167E-01
93	'M4015S1'	TS6X2X.375	1.513E+01	8.750E-01	'FY50'	5.417E+00	5.438E+00	9.167E-01
94	'M4025S1'	TS6X2X.375	1.513E+01	8.750E-01	'FY50'	5.417E+00	5.438E+00	-9.167E-01
TOTAL			4.999E+02	2.892E+01		4.016E+00	3.062E+00	0.000E+00

20 Items Processed.

GROUP: 6   'TS6X4'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
95	'M1302S1'	TS6X4X.500	4.267E+01	1.500E+00	'FY50'	7.500E-01	2.500E-01	0.000E+00
96	'M2302S1'	TS6X4X.500	4.267E+01	1.500E+00	'FY50'	7.500E-01	1.750E+00	0.000E+00
97	'M3302S1'	TS6X4X.500	4.267E+01	1.500E+00	'FY50'	7.500E-01	4.125E+00	0.000E+00
98	'M5302S1'	TS6X4X.500	4.267E+01	1.500E+00	'FY50'	7.500E-01	5.875E+00	0.000E+00
99	'M1012S1'	TS6X4X.500	4.267E+01	1.500E+00	'FY50'	7.500E-01	1.000E+00	9.167E-01
100	'M1022S1'	TS6X4X.500	4.267E+01	1.500E+00	'FY50'	7.500E-01	1.000E+00	-9.167E-01
101	'M2012S1'	TS6X4X.500	6.756E+01	2.375E+00	'FY50'	7.500E-01	2.938E+00	9.167E-01
102	'M2022S1'	TS6X4X.500	6.756E+01	2.375E+00	'FY50'	7.500E-01	2.938E+00	-9.167E-01
103	'M3012S1'	TS6X4X.500	2.489E+01	8.750E-01	'FY50'	7.500E-01	4.563E+00	9.167E-01
104	'M3022S1'	TS6X4X.500	2.489E+01	8.750E-01	'FY50'	7.500E-01	4.563E+00	-9.167E-01
105	'M4012S1'	TS6X4X.500	2.489E+01	8.750E-01	'FY50'	7.500E-01	5.438E+00	9.167E-01
106	'M4022S1'	TS6X4X.500	2.489E+01	8.750E-01	'FY50'	7.500E-01	5.438E+00	-9.167E-01
TOTAL			4.907E+02	1.725E+01		7.500E-01	3.041E+00	0.000E+00

12 Items Processed.

GROUP: 7   'L4X3'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
107	'M3102S1'	L4X3X3/8	3.165E+01	3.750E+00	'FY50'	3.083E+00	4.125E+00	3.750E-01
108	'M3103S1'	L4X3X3/8	1.688E+01	2.000E+00	'FY50'	6.458E+00	4.125E+00	3.750E-01
109	'M3202S1'	L4X3X3/8	3.165E+01	3.750E+00	'FY50'	3.083E+00	4.125E+00	-3.750E-01
110	'M3203S1'	L4X3X3/8	1.688E+01	2.000E+00	'FY50'	6.458E+00	4.125E+00	-3.750E-01
111	'M5401S1'	L4X3X3/8	3.235E+01	3.833E+00	'FY50'	3.083E+00	5.875E+00	3.750E-01
112	'M5402S1'	L4X3X3/8	1.758E+01	2.083E+00	'FY50'	6.458E+00	5.875E+00	3.750E-01
113	'M5403S1'	L4X3X3/8	3.235E+01	3.833E+00	'FY50'	3.083E+00	5.875E+00	-3.750E-01
114	'M5404S1'	L4X3X3/8	1.758E+01	2.083E+00	'FY50'	6.458E+00	5.875E+00	-3.750E-01
TOTAL			1.969E+02	2.333E+01		4.265E+00	5.013E+00	0.000E+00

8 Items Processed.

GROUP: 8   'ASS-LEVR'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
115	'BAR---03'	'BAR 2.500 95010005-3 '	3.157E+01		'A36'	6.667E+00	3.000E+00	0.000E+00
116	'BAR---04'	'BAR 2.000 95010005-4 '	2.339E+00		'A36'	6.667E+00	3.000E+00	0.000E+00
117	'BAR4--05'	'BAR 0.500 95010005-5 '	1.559E+00		'A36'	6.667E+00	3.000E+00	0.000E+00
118	'BAR---07'	'BAR 1.000 95010005-7 '	3.563E+00		'A36'	6.667E+00	3.000E+00	0.000E+00
119	'WASH2-08'	'WASH 1.75 95010005-8 '	1.000E-01		'ZINCPL'	6.667E+00	3.000E+00	0.000E+00
120	'NUTS2-09'	'NUTS HEX 95010005-9 '	2.000E-01		'SAEGR2'	6.667E+00	3.000E+00	0.000E+00
121	'LVRSHF10'	'LEVER 1.00 95010005-10'	4.788E+00		'A36'	6.667E+00	3.000E+00	0.000E+00
TOTAL			4.412E+01			6.667E+00	3.000E+00	0.000E+00

7 Items Processed.

GROUP: 9 'ASS-ROLL'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
122	'WAS40-08'	'WASH 1.75 95010005-8 '	4.000E+00		'ZINCPL'	3.750E+00	3.000E+00	0.000E+00
123	'NUT40-09'	'NUT HEX 95010005-9 '	8.000E+00		'SAEGR2'	3.750E+00	3.000E+00	0.000E+00
124	'KRL28-12'	'ROLLER 8IN 95010005-12'	2.000E+01		'RUBBER'	3.750E+00	3.000E+00	0.000E+00
125	'BAR28-13'	'BAR 0.625 95010005-13'	1.914E+01		'A36'	3.750E+00	3.000E+00	0.000E+00
TOTAL			5.114E+01			3.750E+00	3.000E+00	0.000E+00

4 Items Processed.

GROUP: 10 'ASS-MISC'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
126	'BAR---13'	'BAR 4.00 95010002-13'	1.000E+01		'FY50'	6.667E+00	2.000E+00	0.000E+00
127	'CASING15'	'TUBE 14.25 95010002-15'	3.534E+01		'FY50'	3.177E-01	5.000E+00	0.000E+00
128	'CASING16'	'TUBE 14.25 95010002-16'	4.114E+01		'FY50'	5.365E-01	1.000E+00	0.000E+00
129	'STIFF-18'	'STF 0.500 95010002-18'	2.400E+01		'FY50'	2.865E-01	5.000E+00	0.000E+00
130	'STIFF-19'	'STF 0.500 95010002-19'	2.400E+01		'FY50'	2.865E-01	5.000E+00	0.000E+00
131	'STIFF-20'	'STF 0.500 95010002-20'	2.000E+01		'FY50'	2.865E-01	1.000E+00	0.000E+00
132	'STIFF-21'	'STF 0.500 95010002-21'	2.000E+01		'FY50'	2.865E-01	1.000E+00	0.000E+00
133	'ENDPL-22'	'PLT 0.625 95010002-22'	1.807E+02		'FY50'	0.000E+00	4.000E+00	0.000E+00
134	'PLATE-23'	'PLT 0.500 95010002-23'	1.600E+01		'FY50'	7.396E-01	5.000E+00	0.000E+00
135	'PLATE-24'	'PLT 0.500 95010002-24'	1.800E+01		'FY50'	7.396E-01	1.000E+00	0.000E+00
136	'FUNPL-25'	'FUNNEL 0.5 95010002-25'	8.890E+01		'FY50'	0.000E+00	4.000E+00	0.000E+00
137	'RING--28'	'RING 95010002-28'	1.000E+01		'FY50'	7.396E-01	5.000E+00	0.000E+00
138	'PLATE-XX'	'PLATE 0.500 THK '	8.160E+01		'FY50'	1.000E+00	3.000E+00	0.000E+00
139	'GUILLPLT'	'GUILLOTINE 2.25 THK '	1.320E+02		'FY50'	1.000E+00	1.000E+00	0.000E+00
140	'GUILLPLT'	'GUILLOTINE 2.25 THK '	1.320E+02		'FY50'	1.000E+00	5.000E+00	0.000E+00
TOTAL			8.337E+02			6.037E-01	3.336E+00	0.000E+00

15 Items Processed.

GROUP: 12 'PIN-CASE'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
141	'TUBE--03'	'TUBE 15.75 95010004-3 '	1.710E+02		'FY50'	0.000E+00	5.000E+00	0.000E+00
142	'BAR---04'	'BAR 13.00 95010004-4 '	2.800E+01		'FY50'	0.000E+00	5.000E+00	0.000E+00
143	'BAR---05'	'BAR 15.75 95010004-5 '	5.500E+01		'FY50'	0.000E+00	5.000E+00	0.000E+00
144	'TUBE--06'	'TUBE 15.75 95010004-6 '	1.900E+01		'FY50'	0.000E+00	5.000E+00	0.000E+00
145	'BAR---07'	'BAR 0.75 95010004-7 '	7.500E-01		'FY50'	0.000E+00	5.000E+00	0.000E+00
TOTAL			2.738E+02			0.000E+00	5.000E+00	0.000E+00

5 Items Processed.

GROUP: 13 'PIN-NOSE'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
146	'TUBE--09'	'TUBE 15.00 95010004-9 '	2.931E+01		'FY50'	0.000E+00	5.000E+00	0.000E+00
147	'PIPE--10'	'PIPE 12.00 95010004-10'	6.500E+01		'FY50'	0.000E+00	5.000E+00	0.000E+00
148	'TUBE--11'	'TUBE 12.75 95010004-11'	4.400E+01		'FY50'	0.000E+00	5.000E+00	0.000E+00
149	'TUBE--12'	'TUBE 12.75 95010004-12'	2.700E+01		'FY50'	0.000E+00	5.000E+00	0.000E+00
150	'BAR---13'	'BAR 12.75 95010004-13'	2.480E+02		'FY50'	0.000E+00	5.000E+00	0.000E+00
151	'PLT---14'	'BAR 11.75 95010004-14'	1.140E+01		'FY50'	0.000E+00	5.000E+00	0.000E+00
152	'BRGPLTS	'BAR 11.75 X 0.5 THK '	3.860E+01		'FY50'	0.000E+00	5.000E+00	0.000E+00
TOTAL			4.633E+02			0.000E+00	5.000E+00	0.000E+00

7 Items Processed.

GROUP: 14 'PIN-MISC'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
153	'PINCAP15'	'CAP 12.75 95010004-15'	3.000E+01		'PVC'	0.000E+00	5.000E+00	0.000E+00
154	'PINROD19'	'ROD 95010004-19'	1.626E+01		'FY50'	0.000E+00	5.000E+00	0.000E+00
155	'PINNUT20'	'NUT HEX 95010004-20'	5.000E-01		'SAEGR2'	0.000E+00	5.000E+00	0.000E+00
156	'SPRING21'	'SPRING 95010004-21'	1.877E+02		'FY50'	0.000E+00	5.000E+00	0.000E+00
157	'PINPLT22'	'PIN PLATE 95010004-22'	3.987E+00		'FY50'	0.000E+00	5.000E+00	0.000E+00
TOTAL			2.384E+02			0.000E+00	5.000E+00	0.000E+00

5 Items Processed.

GROUP: 16 'ENC-BHDS'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
158	'BHDPLT	'BHD PLT 0.25 THK '	1.428E+03		'FY50'	0.000E+00	3.000E+00	0.000E+00
159	'BHD-L4X3'	'BHD STF L4X3X3/8 '	9.260E+02		'FY50'	0.000E+00	3.000E+00	0.000E+00
160	'CRNR-PLT'	'STIFF 0.50 THK '	6.120E+01		'FY50'	0.000E+00	3.000E+00	0.000E+00

TOTAL			2.415E+03			0.000E+00	3.000E+00	0.000E+00

3 Items Processed.

GROUP: 17 'ENC--BMS'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
161	'TS6X4BOT'	'TS6X4X.500 '	1.421E+02		'FY50'	0.000E+00	3.000E+00	0.000E+00
162	'TS6X4TOP'	'TS6X4X.500 '	1.042E+02		'FY50'	0.000E+00	3.000E+00	0.000E+00
163	'TS6X2TOP'	'TS6X2X.375 '	6.332E+01		'FY50'	0.000E+00	3.000E+00	0.000E+00
164	'TS6X4SID'	'TS6X4X.500 '	4.549E+02		'FY50'	0.000E+00	3.000E+00	0.000E+00
165	'TS6X2SID'	'TS6X2X.375 '	2.763E+02		'FY50'	0.000E+00	3.000E+00	0.000E+00
166	'PADEYES8'	'PADEYE '	6.000E+01		'FY50'	0.000E+00	3.000E+00	0.000E+00
167	'PIN/NUT4'	'PIN&NUT '	2.000E+01		'FY50'	0.000E+00	3.000E+00	0.000E+00
TOTAL			1.121E+03			0.000E+00	3.000E+00	0.000E+00

7 Items Processed.

GROUP: 18 'ENC-CONN'

ITEM NO.	ITEM ID	ITEM TITLE	ITEM WEIGHT	ITEM LENGTH	ITEM MATL	COG X	COG Y	COG Z
168	'STFPLT24'	'STF PLT 0.500 THK '	5.000E+01		'FY50'	0.000E+00	3.000E+00	0.000E+00
169	'BRGPLT-8'	'BRG PLT 0.250 THK '	5.000E+01		'FY50'	0.000E+00	3.000E+00	0.000E+00
170	'SHIMPLTS'	'SHIMS VARY THK '	3.000E+01		'FY50'	0.000E+00	3.000E+00	0.000E+00
TOTAL			1.300E+02			0.000E+00	3.000E+00	0.000E+00

3 Items Processed.

*** 3 Item Identifiers Processed.

PRINT MTO LEV 2 GROUP 'MATERIAL'

```
**************************************
*  PRINT OUTPUT FROM ASADS DATABASE  *
*  UNITS: FEET   LB  SEC  DEG DEGF   *
**************************************
```

WEIGHT REPORT:
LEVEL 3,   1 GROUPS

WTO LEVEL 0 GROUPS: 1

WTO LEVEL 1 GROUPS: 1

GROUP NO.	GROUP ID	GROUP TITLE	GROUP WEIGHT	GROUP LENGTH	GROUP MATL	COG X	COG Y	COG Z
27	'MATERIAL'		7.520E+03	1.559E+02		9.842E-01	3.385E+00	0.000E+00
TOTAL			7.520E+03	1.559E+02		9.842E-01	3.385E+00	0.000E+00

170 Items Processed.

WTO LEVEL 2 GROUPS: 1

GROUP: 27   'MATERIAL'

GROUP NO.	GROUP ID	GROUP TITLE	GROUP WEIGHT	GROUP LENGTH	GROUP MATL	COG X	COG Y	COG Z
21	'FY50'		7.394E+03	1.559E+02		9.353E-01	3.383E+00	0.000E+00
22	'A36'		6.296E+01			5.780E+00	3.000E+00	0.000E+00
23	'SAEGR2'		8.700E+00			3.602E+00	3.115E+00	0.000E+00
24	'ZINCPL'		4.100E+00			3.821E+00	3.000E+00	0.000E+00
25	'RUBBER'		2.000E+01			3.750E+00	3.000E+00	0.000E+00
26	'PVC'		3.000E+01			0.000E+00	5.000E+00	0.000E+00
TOTAL			7.520E+03	1.559E+02		9.842E-01	3.385E+00	0.000E+00

170 Items Processed.

***   1 Item   Identifiers   Processed.

FIN

PROGRAM   ASADS V2.0 COMPLETED.

*** NUMBER OF JOINTS   :   72
*** NUMBER OF MEMBERS   :   122
*** NUMBER OF LOAD CASES: 38
*** NUMBER OF ITEMS   :   170

*** ERROR MESSAGES: 0
*** WARNING MESSAGES: 0

*** INPUT   FILE: REV3MTO
*** OUTPUT FILE: REV3MTO.OUT

```
*** SAVE    FILE : NONE GIVEN    RUN DATE/TIME: 25-Jan-1996 17:36:51
*** RESTORE FILE : REV3STIF.SAV  RUN DATE/TIME: 19-Dec-1995 14:44:42

*** RUN DATE/TIME : 25-Jan-1996 17:36:51
*** EXECUTION TIME:       32.94 SEC.
```